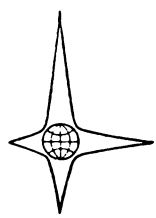
E.DOBROMYSLSKY and I.SHCHERBATOV

Paranasal Sinuses and Diseases of the Orbit



MIR PUBLISHERS

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ПРИДАТОЧНЫЕ ПАЗУХИ НОСА И ИХ СВЯЗЬ С ЗАБОЛЕВАНИЯМИ ГЛАЗНИЦЫ И СЛЕЗООТВОДЯЩИХ ПУТЕЙ

ИЗДАТЕЛЬСТВО «МЕДИЦИНА»
МОСКВА

PARANASAL SINUSES and DISEASES OF THE ORBIT

by
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Translated from the Russian
by Y. Shirokov

MIR PUBLISHERS
MOSCOW 1966

UDC 611.216+616.216 : 617.76(0.22)=20

First published 1964
Second printing

На английском языке

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PREFACE

Some diseases of the paranasal sinuses may extend to the orbit. Since their primary symptoms may well be ophthalmic, such as exophthalmos, it is highly important that both the rhinologist and the ophthalmologist should be capable of recognizing them so as to determine the character of the morbid process.

Cooperation among specialists in these related fields has hitherto been inadequate, since not all realise its urgency.

Rhinologists and ophthalmologists mostly work on their own, having a comparatively little knowledge of the symptoms of related diseases, which is detrimental to early diagnosis and effective treatment.

In diseases of the orbit and the adjacent paranasal sinuses X-rays are now quite indispensable for a competent diagnosis. Only when the X-ray film is available can a correct diagnosis be made and the proper treatment prescribed.

Take mucocele, for example. A typical rhinogenous disease though it is, ophthalmic symptoms are nevertheless quite common to it, and only X-rays will in most cases enable an accurate identification.

Ophthalmologists, however, often neglect this method, and even when they use it, their interpretation and evaluation of X-rays are not up to standard, as will be shown below.

The need for a team approach with the participation of specialists in the adjacent fields is especially acute in cases of combined injuries.

The basic aim of this book is to familiarise the reader, above all the otorhinolaryngologist and the ophthalmologist, with the clinical symptoms, methods of diagnosis, principles of conservative treat-

ment and techniques of surgery for affections of the paranasal sinuses, such as empyema, non-inflammatory processes, tumours, etc., which often extend to the orbit and orbital contents.

In addition to a review of the traditional methods of surgery of the paranasal sinuses and the orbit, a description is given of combined operations on the orbito-sinual region, developed by V. I. Voyachek, V. P. Filatov, N. K. Lysenkov, S. S. Golovin, and other scientists.

The book is based on the current reports and records of the Helmholtz Institute of Ophthalmology, studies of the E.N.T. clinic of the Department of Pediatrics at the Pirogov Second Medical Institute, Moscow (affiliated with the Filatov Hospital), as well as on the authors' personal experience. Chapter II and the section "The Orbit" in Chapter I have been contributed by Prof. M. M. Baltin.

1

Clinical Anatomy of the Nose, Paranasal Sinuses, Orbit and Lacrimal Apparatus

THE NASAL CAVITY

The nasal cavity is situated between the orbits, the oral cavity and the anterior cranial fossa (Fig. 1). On the front side it communicates through the nostrils with the external environment and

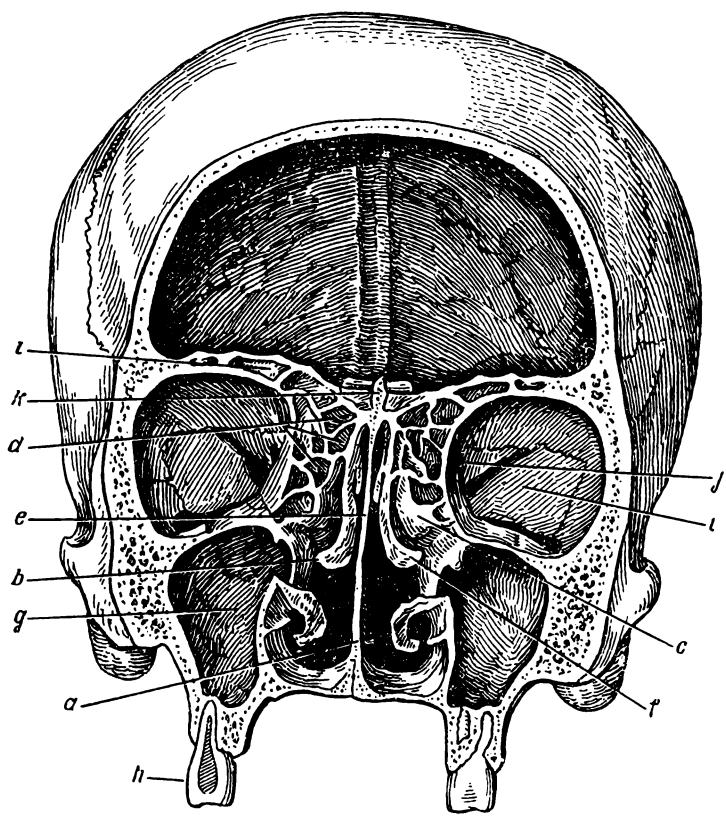


Fig. 1. Bony framework of the nasal cavity; anterior portions. Front view (after V. P. Vorobyov)

a—nasal septum; *b*—middle nasal turbinate; *c*—bulla ethmoidalis; *d*—an ethmoid cell; *e*—lamina perpendicularis ossis ethmoidalis; *f*—middle nasal turbinate; *g*—maxillary sinus; *h*—third molar; *i*—orbital surface of the great wing of the sphenoid bone; *j*—optic foramen; *k*—crista galli; *l*—posterior portions of the frontal sinus

on the rear side it communicates through the choanae with the upper portion of the pharynx (nasopharynx). The nasal septum divides the nasal cavity into two noncommunicating halves (right and left), each with an external orifice and a choana.

The nasal vestibule (vestibulum nasi). The skin covering the external nose continues inward into the vestibule and retains its properties all along its length; it is overgrown with a considerable number of hairs (vibrissae), particularly in elderly men. These hairs serve as a filter catching the larger dust particles, but in some cases they may become the source of a furuncle as they harbour staphylococci in their bulbs.

The entrance to the bony portion of the nose (apertura piriformis), whose edges are formed by the frontal processes of the maxilla and the lower margins of both nasal bones, has a pear-shaped outline.

Being a continuation of the nasal vestibule, the nasal cavity lies within a bony framework, and is lined with a mucous membrane. Apart from the nasopharynx, it communicates with the paranasal sinuses and through the foramen sphenopalatinum with the pterygopalatine fossa, as well as with the nasolacrimal duct, and through the latter with the conjunctival sac.

The duct in each half of the nasal cavity is limited by four walls: the internal (common for both halves), the external, the superior (roof) and the inferior (floor).

The internal, or medial, wall is the nasal septum. It consists of a perpendicular plate (lamina perpendicularis ossis ethmoidalis; Fig. 1*e*) hanging down and supplemented at the bottom and rear with the vomer and on the front with the quadrilateral cartilage, which on the border of the nasal cavity and vestibule turns into the cutaneous portion of the nasal septum. The latter two portions represent the mobile part of the nasal septum as distinct from its immobile posterior bony portion.

The external wall of the nasal cavity, which is continuous with the internal wall of the maxillary sinus, is the most complicated for its anatomical structure. A knowledge of its topographical anatomy is necessary both for the rhinologist and the ophthalmologist, since it lodges the nasolacrimal duct.

The external wall (Figs. 2 and 3) is formed of the nasal bone, the nasal (medial) surface of the supramaxillary bone with its frontal process, the lacrimal bone, the ethmoid bone (with its superior and middle nasal turbinates, the bulla ethmoidalis, and the processus uncinatus), the vertical plate of the palate bone and the pterygoid process of the sphenoid bone, which takes part in forming the choana. Apart from the superior and middle nasal turbinates (Fig. 2*n* and *m*) belonging to the ethmoid bone, the external nasal wall has the inferior nasal turbinate (Fig. 2*e*), which is an independent bone (os turbinale). Anteriorly, its upper edge is attached to the linear eminence (crista turbinalis) of the frontal process of the maxilla, and

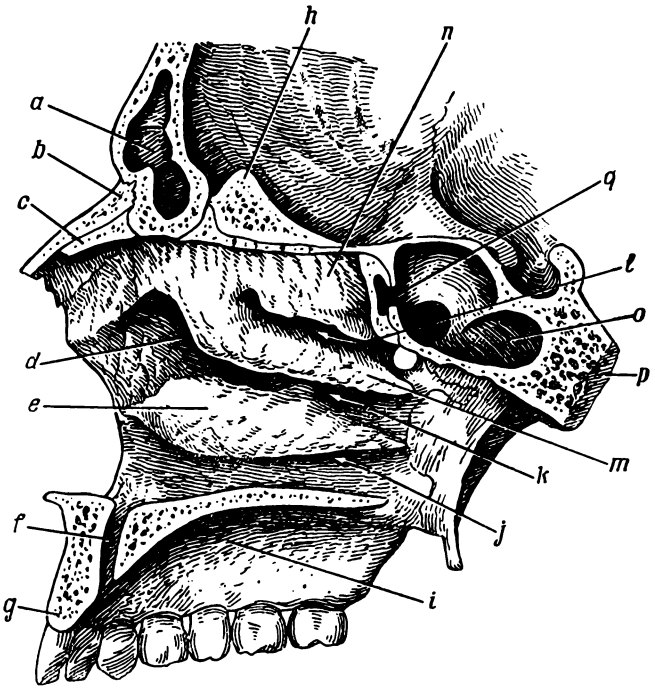


Fig. 2. External wall of the nasal skeleton (after V. P. Vorobyov)

a—frontal sinus; *b*—nasal bone; *c*—spina frontalis; *d*—lacrimal bone; *e*—inferior nasal turbinate; *f*—canalis incisivus; *g*—alveolar process; *h*—crista galli; *i*—palate process of the superior maxillary bone; *j*—inferior nasal meatus; *k*—middle nasal meatus; *l*—superior nasal meatus; *m*—middle nasal turbinate; *n*—superior nasal turbinate; *o*—sphenoid sinus; *p*—foramen sphenopalatinum; *q*—natural orifice of the sphenoid sinus

posteriorly, to the crest of the palate bone. Under the vault of the inferior nasal turbinate and 25 to 30 mm from the appertura piriformis lies the round or oval outlet of the nasolacrimal duct (Fig. 3*h*). For full details see the section "Lacrimal Passages".

Corresponding to the three nasal turbinates are the three nasal meatuses: the inferior (space between the inferior nasal turbinate and the nasal cavity floor), the middle (between the middle and the inferior nasal turbinates) and the superior (above the middle turbinate), shown in Fig. 2*j*, *k*, *l*.

From the clinico-diagnostical aspect, the most important part of the external wall of the nasal cavity is the middle nasal meatus (Fig. 2*k*) into which open the outlets of the maxillary and frontal sinuses, as well as the anterior and some of the middle cells of the ethmoid labyrinth.

On a macerated skull this portion corresponds to the hiatus maxillaris which is considerably narrowed since it is covered by bony formations (unciform process of the ethmoid bone, processes of the inferior nasal turbinate).

The places devoid of bone are covered by fontanels, i.e., duplicatures of the accreted layers of the mucosa of the nasal and maxil-

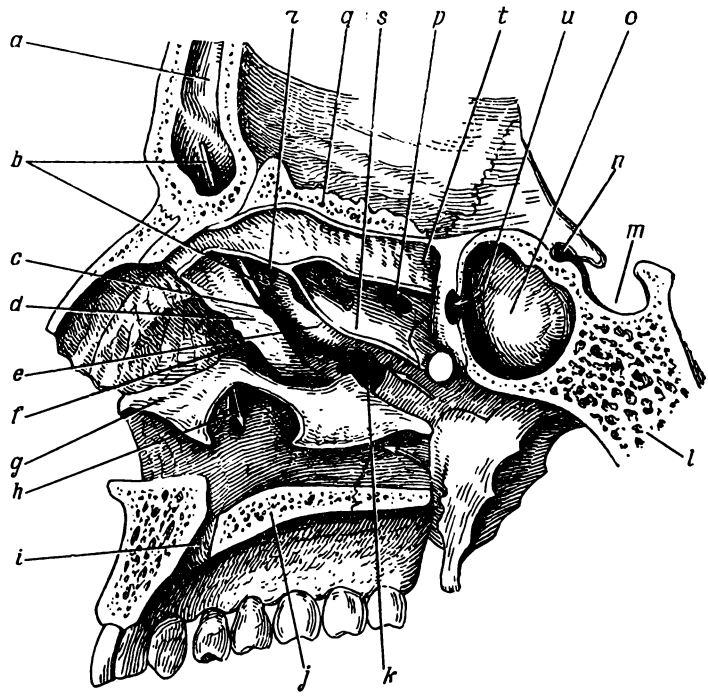


Fig. 3. External wall of the nasal skeleton after removal of the superior, middle and part of the inferior nasal turbinate (after V. P. Vorobyov)

a—frontal sinus; *b*—a probe passed from the frontal sinus into the semilunar fissure; *c*—semicanalis obliquus (hiatus semilunaris); *d*—processus uncinatus ossis ethmoidalis; *e*—bulla ethmoidalis; *f*—os lacrimale; *g*—inferior nasal turbinate; *h*—a probe in the nasolacrimal duct; *i*—canalis incisivus; *j*—palatine process of the superior maxillary bone; *k*—maxillary sinus; *l*—body of the sphenoid bone; *m*—Turkish saddle; *n*—optic foramen; *o*—sphenoid sinus; *p*—orifice of the posterior ethmoid cells: *q*—cribriform plate; *r*—orifice of the anterior ethmoid cells; *s*—middle nasal turbinate (cross-section); *t*—superior nasal turbinate (cross-section); *u*—natural orifice of the sphenoid sinus

lary sinuses. There are usually two fontanels: the posterior which is limited by the ethmoid process, the posterior end of the unciform process and the perpendicular plate of the palate bone; and the anterior, which is situated between the unciform process, the inferior nasal turbinate and its ethmoid process.

The removal of a part or the whole of the middle nasal turbinate will expose a semilunar or sickle-shaped fissure (hiatus semilunaris; Fig. 3*c*), which was first described by N. I. Pirogov, who named it the semicanalis obliquus.

In front and below the fissure is limited by the above-mentioned unciform process of the ethmoid bone (Fig. 3*d*) with bony outgrowths directed downward and backward, in back and above by a rounded projection from one of the ethmoid cells (bulla ethmoidalis; Fig. 3*e*). Small fissures between separate prominences of the unciform process lead to the maxillary sinus; on a fresh preparation they are covered by the duplicature of the mucous membrane save for the

posterior part of the semilunar fissure, which serves as a permanent orifice of the maxillary sinus (ostium maxillare). The rear part of the semilunar fissure has a funnel-shaped expansion narrowing towards the maxillary sinus, which has its outlet (ostium maxillare) in its floor.

In addition to the permanent orifice, the maxillary sinus often has an accessory orifice (ostium maxillare accessorium), which also opens into the middle nasal meatus.

The frontal sinus opens out into the antero-superior part of the semilunar fissure (ductus nasofrontalis; Fig. 3*b*).

The anterior and part of the posterior cells of the ethmoid labyrinth usually open out at the anterior and posterior walls of the semilunar fissure, as well as at the corner between the bulla ethmoidalis and the middle nasal turbinate. Sometimes one of the anterior cells of the ethmoid labyrinth opens out beside the outlet of the frontal sinus.

The posterior and part of the middle cells of the ethmoid labyrinth, as well as the sphenoid sinus, open out through their outlets into the superior nasal meatus and into the depression between the surface of the sphenoid bone and the superior nasal turbinate (recessus spheno-ethmoidalis).

The roof of the nasal cavity is mainly formed of the cribriform plate of the ethmoid bone (lamina cribrosa) supplemented anteriorly with the frontal and nasal bones and the frontal processes of the maxilla, and posteriorly—with the anterior wall of the sphenoid sinus.

This plate (Fig. 3*q*) is perforated with a large number of openings which serve to transmit slender filaments (fila olfactoria) leading from the olfactory cells through the olfactory bulb (bulbus olfactorius) to the olfactory nerve. The bulbs of the olfactory nerve lie on the cranial surface of the cribriform plate of which they occupy two thirds on both sides of the crista galli.

The openings of the plate also serve to transmit the anterior ethmoidal artery, veins and nerve from the nose into the cranial cavity.

The inferior wall of the nasal cavity is formed by the palate processes of the maxilla, which posteriorly are supplemented by the horizontal plates of the palate bone, and is concave in the frontal and sagittal plane.

The mucous membrane lining the respiratory region of the nose from the vestibule to the olfactory region is covered by a stratified, columnar, ciliated epithelium. The mucous membrane of the olfactory region extends to the surface of the superior turbinate, the upper portion of the middle turbinate and the corresponding part of the nasal septum. It is lined with a special olfactory epithelium made up of the olfactory and the supporting cells. The former are the peripheral nerve endings of the olfactory analysor.

The arteries of the nasal cavity take their origin from the common and external carotid arteries.

Arterial supply comes through the a. sphenopalatina from the a. maxillaris interna—the 8th branch of the external carotid artery passing from the fossa pterygopalatina into the nasal cavity through the foramen sphenopalatinum and ramifying here into the aa. nasales posteriores with their branches (the a. nasalis posterior lateralis and the a. nasalis posterior septi nasi) and the a. nasopalatina. Through the above-mentioned branches arterial blood is supplied to the inferior, middle and superior nasal turbinates, the corresponding nasal meatuses and to a part of the nasal septum.

The upper portion of the external nasal wall and partially the septum receive blood from the anterior and posterior ethmoidal arteries which are the branches of the a. ophthalmica.

The veins of the nasal cavity pass alongside the arteries of the same name. A large number of venous plexuses connect the veins of the nasal cavity with those of the orbit, skull, face and pharynx. The connection the anterior and posterior ethmoidal veins have with the orbital veins, as well as with the cavernous sinus through the ophthalmic veins, is a major factor in the pathogenesis of orbital inflammations. A branch of the anterior ethmoidal vein, which penetrates through the cribriform plate into the cranial cavity, connects the nasal cavity and the orbit with the venous plexus of the pia mater.

The lymphatic system of the nasal cavity consists of a superficial and a deep-seated layer of vessels linked with the subdural and subarachnoid spaces of the meninges.

The sensory innervation of the nasal cavity is effected through the 2nd branch of the trigeminal nerve, as well as through the sphenopalatine ganglion (ganglion sphenopalatinum).

The 1st branch of the trigeminal nerve (n. ophthalmicus and its branch n. nasociliaris) is connected with the nasal cavity through the nn. ethmoidales anterior and posterior, as well as through the rr. nasales mediales and laterales.

The 2nd branch of the trigeminal nerve (n. maxillaris) extends to the nasal cavity through the branches of the n. infraorbitalis rr. nasales externi and interni.

From the olfactory epithelium of the nasal mucosa the nerve fibres of each side pass through the openings in the cribriform plate to the olfactory bulb and then unite in a common stem as part of the tractus olfactorius and the trigonum olfactorium to reach first the subcortical olfactory centres in the grey matter and then the brain cortex (gyrus hippocampi and gyrus subcallosus).

The connection between the nerves of the nasal cavity and those of the eye lies through the n. nasociliaris and the ganglion nasociliare.

Sympathetic innervation is effected through connection with the superior cervical sympathetic ganglion. The appropriate fibres

extending from the plexus caroticus lead to the gasserian ganglion wherefrom they penetrate into the nasal cavity, paranasal sinuses and orbit as part of the n. ophthalmicus and the n. maxillaris. Most of the fibres pass as part of the n. maxillaris through the sphenopalatine ganglion and then ramify in the nasal cavity and paranasal sinuses. The lesser part of the fibres (anterior and posterior ethmoidal nerves—branches of the n. ophthalmicus) penetrate into the nose through the corresponding openings in the internal wall of the orbit.

The parasympathetic fibres which take their origin from the corresponding centres of the medulla oblongata form a part of the facial nerve and through the n. petrosus major reach the sphenopalatine ganglion where they break off and then reach the nasal cavity and orbit in the form of post-ganglionic fibres.

It follows from the aforesaid that there is a close connection between the nasal cavity, its accessory sinuses and the orbit. This is due to the trigeminal sympathetic and parasympathetic innervation through the ganglion cervicale superior, ganglion Gasseri, ganglion ciliare (in the orbit) and ganglion sphenopalatinum (in the nose).

THE PARANASAL SINUSES

The paranasal sinuses lying within the facial skeleton are air-filled cavities lined with a thin mucous membrane with few vessels and glands, which acts as a periosteum and is an extension of the nasal mucosa.

The paranasal sinuses are formed by the mucous membrane of the middle nasal meatus growing into cavernous bony tissue. Coming in contact with bony tissue, the mucous membrane causes its resorption, and the formation in the nasal meatuses of prominences and lacunae constituting the rudiments of the paranasal sinuses.

The paranasal sinuses begin to develop in the 9th or 10th week of embryonal life, the rudiments of the maxillary sinus and ethmoid labyrinth being the first to appear (8th week). The newborn has all the paranasal sinuses fully developed save for the frontal sinuses, which are in a rudimentary state. The variety of forms and sizes of individual sinuses and their inadequate development or even underdevelopment (of the frontal sinuses in particular) not only in different individuals but even in one and the same subject are due to inflammatory diseases of the nasal mucosa sustained in early childhood, when the paranasal sinuses are formed and the resorptive capacity of the mucous membrane decreases.

The paranasal sinuses lie in direct proximity to such vital organs as the orbit with its contents and the middle cranial fossa. In describing the clinical anatomy of the sinuses, which are called "periorbital" cavities (not without reason, since only the external part of the

orbit is out of contact with them) we shall therefore dwell in detail on the relationships between the paranasal sinuses and the orbit.

The maxillary sinus, or the antrum of Highmore (sinus maxillaris sive Highmori; see Fig. 1), lies within the body of the superior maxillary bone, and is the largest of all the paranasal sinuses.

In the newborn it appears as a small fissure, or depression, between the external wall of the nose, the orbit and rudimental teeth. This depression is 7 to 14 mm in length, 5 to 10 mm in height, and 3 to 5 mm in width (L. I. Sverzhevsky). By the end of the first year of life the sinus becomes round in form, and its size grows from 10 to 12 mm lengthwise and 3 to 9 mm across. Until the age of 7 it grows slowly; since the age of 7 it grows faster and becomes fully developed at the age of 15 to 20. The location of the maxillary sinus with regard to the orbit and the alveolar process changes with age. In a nurseling, the inferior wall of the orbit lies above the two rows of rudimentary deciduous and permanent teeth, while the fissure of the maxillary sinus lies only partially above the tooth rudiments and has no direct relationship to them (A.I. Feldman and S. I. Wulfson).

The maxillary sinus of an adult resembles an irregular pyramid with four walls: the anterior (facial), the superior (orbital), the posterior and the interior. The base of the pyramid is the inferior wall, or floor, of the sinus.

The sinuses lying on both sides are not always of identical size, and are often asymmetric. This should be borne in mind when evaluating X-ray evidence. The size of the sinus depends mainly on the thickness of its walls: if the latter are thin the sinus will be large, and vice versa.

The superior wall of the maxillary sinus which is in part the inferior wall of the orbit forms the orbital surface of the superior maxillary bone, and is the thinnest of all the walls of the sinus. On the orbital surface, from behind forward, lies a groove (sulcus infraorbitalis) lodging the n. infraorbitalis (from the n. maxillaris). Near the edge of the orbit the groove turns into a channel (canalis infraorbitalis) which passes downward and forward, boring, so to speak, through the angle formed by the orbit and the facial wall of the sinus, and ends in the latter—somewhat below the orbital boundary—as the infraorbital foramen (foramen infraorbitale; see Fig. 72) transmitting the n. infraorbitalis, infraorbital artery and vein to the facial wall.

The inferior wall of the infraorbital nerve canal usually forms a bony prominence into the maxillary sinus; the bone in this portion is very thin or may be absent altogether. Frequently it has dehiscences (gaps) situated either in the inferior wall of the nerve canal or in other sections of the orbital wall. These structural peculiarities account for the extension of the inflammatory process to the orbit, for the development of neuralgia and for nerve injuries in careless

cleansing of the mucosa of the triangle-shaped superior wall of the sinus. This wall in its anterior portion has its internal margin connected with the lacrimal bone and contributes to the formation of the superior orifice of the nasolacrimal duct; it is connected farther with the papyraceous lamina of the ethmoid bone and finally, in the posterior portion, with the orbital process of the palate bone. Outwardly, the superior wall reaches as far as the infraorbital fissure which separates it from the great wing of the sphenoid bone. The superior wall sometimes extends so far backwards as almost to reach the optic foramen, from which it is separated only by the thin ridge of the lesser wing of the sphenoid bone.

The anterior (facial) wall of the maxillary sinus extends from the infraorbital margin to the alveolar process of the maxilla. In the majority of cases it deviates from the latter to such an extent that it may be mistaken for the lateral wall.

In the upper portion of the facial wall the infraorbital nerve emerges from a canal and divides into several branches leading to the upper teeth (rr. alveolares superiores, r. alveolaris medius, r. alveolaris superior anterior, rr. nasales, etc.). In the middle portion of the anterior wall of the sinus there is a depression—the canine fossa (fossa canina; see Fig. 72)—where the anterior wall is thinnest, and therefore most suitable for the surgical opening of the maxillary sinus (see Chapter VII).

The internal wall of the maxillary sinus serves simultaneously as the external wall of the nasal cavity. In the area of the inferior nasal meatus this wall is formed of bone; in the area of the middle nasal meatus it is partially membranous. Here the mucous membranes of the maxillary sinus and the nose come in contact, forming the anterior and posterior fontanels which are separated by the unciform process (Fig. 3*d*). In the depth of the anterior portion of the internal wall passes the nasolacrimal duct, which opens out beneath the inferior nasal turbinate below its point of attachment, i.e., in the inferior nasal meatus.

The outlet of the maxillary sinus (ostium maxillare) is in the supero-posterior portion of the internal wall of the semilunar fissure (semicanalis obliquus). The size of this aperture, which often has an oval shape, varies from 3 to 19 mm in length and from 3 to 6 mm in width.

In some cases, apart from the principal outlet there is an additional orifice (ostium maxillare accessorium) situated behind and below the former.

The high position and oblique direction of the outlet duct of the sinus interfere with the drainage of its pathological contents. In addition, the position of the outlet in the sinus itself does not correspond to that of the nasolacrimal orifice but lies at a distance of 1 cm from it. In view of this fact the method of puncturing the sinus through the inferior nasal meatus is broadly applied both

for diagnosis and for draining the sinus. The puncture is performed through the external wall of the nasal cavity under the inferior nasal turbinate, immediately under its point of attachment and somewhat behind the nasal orifice of the nasolacrimal duct. This part of the bone is very thin.

The posterior wall of the maxillary sinus corresponds to the maxillary tuber (tuber ossis maxillae superioris); it passes backwards from the zygomatic process (proc. zygomaticus) and faces the sphenopalatine fossa (fossa sphenopalatina). This wall, and especially its postero-superior angle, closely approaches the posterior group of the ethmoid cells and the sphenoid sinus.

The close proximity of the posterior wall of the sinus to the ganglion sphenopalatinum with its branches, the plexus pterygoideus, and the a. maxillaris with its branches is of great clinical interest to rhinologists and ophthalmologists, since it may be the cause of a process extending from the maxillary sinus to the posterior cells of the ethmoid labyrinth, to the sphenoid sinus, and through the veins of the plexus pterygoideus to the orbital veins and the cavernous sinus.

The inferior wall, or floor, of the maxillary sinus is formed by the alveolar process of the maxilla as part of the hard palate; it extends from the maxillary tuber to the first premolar tooth. The limits of the sinus floor may reach as far as the alveola of the canine tooth, incisors and wisdom tooth.

The lowest point in the maxillary sinus is the region of the first molar and second premolar. Since the roots of these teeth are the nearest to the sinus, and the bony plate separating it from the alveolar roof of these teeth is here thinnest this section is usually chosen for opening the maxillary sinus from the alveolar side. This method, suggested first by Prof. I. F. Busch of St. Petersburg, and then by A. P. Cooper, is rarely used now.

The infraorbital (prelacrimal) bay formed by the bulging of the floor of the infraorbital canal into the sinus and connecting the latter with the orbit also deserves the attention of rhinologists and ophthalmologists. When the prelacrimal bay extends upwards and inwards it surrounds the lacrimal sac from behind.

The infraorbital bay often extends to the anterior cells of the ethmoid labyrinth and to the nasolacrimal duct.

In the area of the postero-superior angle the maxillary sinus borders on the cranial cavity.

It is a rare anomaly when the maxillary sinus is divided by bony partitions into two communicating or isolated halves.

A continuous septum dividing the maxillary sinus into two noncommunicating cavities was described by Zuckerkandl, L. I. Sverzhevsky, Hajek, Oppikofer, Gruber and Albrecht; a transverse septum was generally observed and only Zuckerkandl, and Waldelberg reported a longitudinal septum (N. I. Mikhaloits).

The ethmoid labyrinth (labyrinthus ethmoidalis, cellulae ethmoidales; see Fig. 1). The anterior cells of the ethmoid labyrinth spring from the anterior end of the middle nasal meatus in the 13th week of embryonal life. One of the four anterior cells may form the frontal sinus by growing into the frontal bone; the posterior ethmoid cells stringing from the blind end of the superior nasal meatus grow towards the roof of the nasal cavity. In the newborn the ethmoid labyrinth consists of several cells lined with a mucous membrane; by the age of 12 to 14 it takes its final shape and commonly consists of 8 to 10 cells. In rare cases no partitions exist between the cells, which thus form one large cavity (cavum ethmoidale).

The ethmoid cells form in the ethmoid bone (os ethmoidale). The latter consists of a medial vertical perpendicular plate (lamina perpendicularis) and two lateral parts which contain the cells of the ethmoid labyrinth connected to each other by the cribriform plate (lamina cribrosa) at the top.

The perpendicular plate (lamina perpendicularis; see Fig. 1*e*) forms the upper portion of the nasal septum. Its extension in the cranial cavity is the crista galli (see Fig. 1*k*). Below the cribriform plate the anterior edge of the perpendicular plate borders on the frontal and nasal bones, and the posterior end borders on the crista sphenoidalis.

As noted above, the cribriform plate lies on both sides of the crista galli. It has about 30 small openings to transmit the branches of the olfactory nerve, as well as the anterior ethmoidal artery, vein and nerve.

The external portion of the ethmoid labyrinth is limited by a thin bone—the papyraceous lamina (lamina papyracea; Fig. 4*d* and 5*a*)—and by the external wall of the nose from the inside.

The cells of the ethmoid labyrinth lie in the space between the papyraceous lamina and the external wall of the nose formed by the ethmoid bone. The ethmoid labyrinth has cells which open out into the middle nasal meatus (anterior portion of the semilunar fissure) and posterior cells which open out into the superior nasal meatus and border on the sphenoid sinus. Anteriorly, the ethmoid cells extend beyond the limits of the papyraceous lamina; they are covered by the lacrimal bone and the frontal process of the maxilla from the outside.

The number, size and location of the ethmoid cells are not constant. The most frequent cell is the bulla ethmoidalis (see Figs. 3*e* and 1*c*), situated in the lower part of the ethmoid labyrinth.

Less frequent cells are the bulla frontalis (found in 2 out of every 10 cases) and the bulla frontoorbitalis. While the former penetrates into the frontal sinus or bulges into its space, forming a kind of accessory frontal sinus, the bulla frontoorbitalis lies along the superior wall of the orbit, i.e., in the horizontal plate of the frontal bone. One should distinguish between the anterior frontoorbital cells

originating in the anterior ethmoid cells and spreading far laterally, and the posterior cells formed by a far forward extension of the posterior ethmoid cells. The posterior ethmoid cells may reach as far as the Turkish saddle (sella turcica).

In addition to the frontal and frontoorbital cells, the agger cellulae and cellulae lacrimales may be found in front of the middle turbinate, and the concha bullosa in the middle turbinate.

The above-described ethmoid cells (permanent and occasional) serve, in case of their considerable spreading, to ensure extensive contact between the ethmoid labyrinth, the adjacent structures (lacrimal sac, optic nerve, etc.) and the cranial cavity, which fact explains the pathogenesis of various syndromes complicating the basic pathological process in the labyrinth.

In clinical practice rhinologists and ophthalmologists pay great attention to the topographo-anatomical relationships between the posterior ethmoid cells and the facial nerve canal.

In case of a considerable pneumatisation of the lesser wing of the sphenoid bone the optic nerve canal is often lodged within a posterior ethmoid cell. According to L. I. Sverzhevsky, in two out of every three cases this canal forms from the wall of the above-mentioned cell. If large, this cell may contribute to the formation of the internal and inferior walls of both canals and even come in contact with the optic commissure.

The variations of the ethmoid cells as to number, size and location are so considerable that Onodi has established 12 groups of different relationships between them and the optic nerve canal. According to Onodi, the posterior ethmoid cells may merge into the frontal sinus, the optic nerve passing in the same cavity, or they may take part in forming one or several walls of the canal and, sometimes, of the canal on the opposite side. In such cases the cells of one side reach over to the opposite side.

The extension of the inflammatory process from the ethmoid labyrinth to the orbit, the optic nerve, the cranial cavity and the other accessory sinuses is facilitated not only by the above-mentioned anatomo-topographical peculiarities but also by the weak resistance of the papyraceous lamina, dehiscences and, finally, by the fact that the orifices of the frontal and maxillary sinuses, as well as the anterior cells of the ethmoid labyrinth, open out into the middle nasal meatus.

The frontal sinus (sinus frontalis: see Figs. 2 and 5) develops from an anterior ethmoid cell which has grown into the frontal bone. In the newborn the frontal sinus is in a rudimentary state and begins to develop only at the end of the first year of life.

Until the age of 6 to 7 this growth is slow, and the sinus remains rudimentary. After this age it is distinctly visible between the external and internal cortical plates of the frontal bone. In the 8th year both frontal sinuses are well developed, although their growth

continues. By the age of 12 to 14 the sinus stops growing in the medial and lateral directions, though it continues to grow in height and acquires its full size by the age of 25.

The average size of the sinus: height from the superciliary arches upward—21 to 23 mm; width from the interfrontal septum—24 to 26 mm; depth—6 to 15 mm. Larger sinuses are also encountered.

In some cases the sinus may bulge into and form a bay in the crista galli. This can be observed in the case of deviation of the interfrontal septum from the median line. Occasionally one encounters an anatomical structure called a "dangerous frontal bone", where careless manipulation of a curette at operation may result in removing the crista olfactoria, which is often followed by meningitis. Moreover, cases of absence of the frontal sinus have been observed, more frequently on both sides (5 per cent), less frequently on one side (1 per cent).

In an adult the frontal sinus is lodged in the squama of the frontal bone and in most cases extends into its horizontal plate (orbital part). The sinus is shaped like a three-edged pyramid (see Fig. 2*a*) with a part of the superior orbital wall forming its floor; the roof of the sinus lies where the anterior, facial wall merges into the posterior, cerebral wall. The sinus comprises the anterior wall (paries frontalis), the posterior wall (paries cerebralis), the inferior wall (paries orbitalis) and the internal wall (interfrontal septum) which divides the space within the frontal bone into two halves: the right and the left frontal sinuses.

The thickest of the walls of the sinus is the anterior (facial) wall, ranging from 1 to 8 mm and thickest in the area of the superciliary arches (arcus superciliaris). On the anterior surface, somewhat above the superciliary arches, lie the frontal tubers (tubera frontalia) separated from the former by slight depressions. Between the arches lies a flat surface—the bridge of the nose. In the medial portion of the supraorbital margin (margo supraorbitalis) there is an opening or incisure (foramen supraorbitale sive incisura supraorbitalis).

The inferior wall, or floor, of the sinus separates it from the orbit, and is the thinnest of all the walls. It consists of the nasal and orbital portions. The nasal portion lies above the nasal cavity and the orbital portion—more laterally, above the orbit itself.

The boundary between these portions is the upper margin of the lacrimal bone. In large sinuses the inferior wall reaches as far as the lacrimal bone and papyraceous lamina; it may cover the entire surface of the orbital roof, border on the lesser wings of the sphenoid bone, the sphenoid sinus, and the optic foramen, forming the latter's superior wall, and reach the middle cranial fossa. This close proximity to the vital organs may contribute to diseases of the orbit, the eyeball, the optic nerve and even the brain substance.

The posterior (cerebral) wall consists of the lamina vitrea of the frontal bone; it contains no diploetic tissue and is therefore so thin as to be translucent when placed in front of a source of light.

The posterior wall merges into the inferior wall at right angles, forming the angulus cranio-orbitalis.

The internal wall (interfrontal septum) lies in the saggital plane, generally along the median line, i.e., above the root of the nose. The superior portion of the septum often deviates from the median line to one side or the other to produce asymmetry of the sinuses.

The frontal sinus is more likely to vary in form and extension than the other sinuses, depending on the degree of resorption of the frontal bone.

The nasofrontal duct (ductus nasofrontalis), which begins from the inferior wall of the sinus at the boundary with the septum and near the posterior wall, connects the sinus with the nasal cavity. This duct appears as a narrow meandering fissure 12 to 16 mm long and 1 to 5 mm wide, which usually ends in the semilunar fissure of the middle nasal meatus, in front of the orifice of the maxillary sinus.

Examples may be found in literature of an atypical location of the frontolacrimal duct and its nasal orifice, which may open out either into the anterior cell of the ethmoid labyrinth, or next to this cell, or else in front of the infundibulum.

The sphenoid sinus (sinus sphenoidalis; see Fig. 2*o*) develops early in the 3rd month of intrauterine life in the supero-posterior portion of the nasal cavity and has the form of a blind sac. It is regarded as a detached posterior ethmoid cell, which develops fully by the age of puberty.

The sphenoid sinus lies within the body of the sphenoid bone and its average size is 9 to 60 mm in length and width, and 9 to 42 mm in height. This sinus has the following six walls: superior, inferior, anterior, posterior, internal and external.

The superior wall, which ranges in thickness from 1 to 7 mm, contains the following formations: the roots of the lesser wings with the optic foramina, and the Turkish saddle (sella turcica) with the hypophysis (hypophysis cerebri) lying in its depression. The diaphragm covering the hypophysis separates it from the optic commissure (chiasma opticum) lying in front and above.

Depending on the degree of pneumatisation, the optic nerve canals and the chiasm may lie so close to the sphenoid sinus as to be separated from it only by a very thin bony plate, or they may be comparatively far from the superior wall of the sinus. In the former case, the wall of the optic nerve canal may be formed by the superior wall of the sinus which, just as the posterior ethmoid cells, may take part in forming the trigonum praesellare, i.e., the region between the optic nerve and the chiasm.

The inferior wall of the sphenoid sinus partially constitutes the rearmost part of the nasal cavity roof and takes part in forming

the nasopharyngeal arch. In the lateral parts of the inferior wall there are depressions lodging the n. Vidianus. If the sphenoid sinus communicates with the nasopharynx through a canal there is reason to suggest a maldevelopment, namely, an unclosed cranio-pharyngeal canal of the fetal period.

The anterior wall. The upper portion of this wall contains the outlets (foramina sphenoidalia; see Fig. 3*u*) of the right and left sinuses, which open out into the recessus sphenoethmoidalis. The level of their position is variable. These outlets may be oval, round or fissural in form and range in size from 0.5 to 5 mm. The anterior wall borders on the posterior ethmoid cells, but sometimes the sphenoid sinus looks like an extension of a cell. In such cases, the recessus sphenoethmoidalis, i.e., the niche covered by the posterior ethmoid cells, is usually absent.

The posterior wall of the sinus is very thick. It is connected with the occipital bone and limited by the upper portion of the clivus of Blumenbach. In marked pneumatisation the posterior wall appears to be thinned down, and the sinus grows to a considerable size.

The lateral walls of the sphenoid sinus have on each side a canal for the internal carotid artery and for the cavernous sinus. The oculomotor, trochlear, trigeminal and abducens nerves pass close to the lateral wall.

The internal wall (interfrontal septum) divides the sphenoid sinus into two halves; in the majority of cases only its anterior part retains its vertical position in the saggital plane. In the rear portion the septum deviates to one side, as a result of which one of the sinuses becomes larger. In marked asymmetry both optic nerves may sometimes adhere to the same sinus. This anomaly is interesting in that it offers an explanation for the bilateral lesion of the optic nerve in a unilateral lesion of the sphenoid sinus, which is sometimes observed in clinical practice.

The sphenoid sinus lies in close proximity to the grey tubercle, to the lower surface of the frontal and temporal lobes of the brain, and to the bridge of Varolius.

The various types of anatomo-topographical relationships between the sphenoid sinus and the optic nerve deserve special attention from rhinologists and ophthalmologists.

M. I. Volfkovich and L. V. Neimann have specially studied this problem and established the following relationships.

1. The intracranial section of the optic nerve adheres to the sinus all along its length.

2. The optic nerve adheres to the sinus, but is separated from it by a thick wall.

3. The optic nerve adheres to the ethmoid cells while the sphenoid sinus is displaced to the rear by the labyrinth.

4. The wall of the optic nerve canal is thin and looks as if it were pressed into the sinus.

5. The presence of dehiscences in the walls of the optic nerve canal makes it directly adherent to the sphenoid sinus.

Arterial blood is supplied to the paranasal sinuses both through the system of the internal carotid artery (branches of the a. ophthalmicae—the aa. ethmoidales anterior and posterior) and through the system of the external carotid artery (branches of the external and internal maxillary arteries—the aa. nasales posteriores and the a. nasopalatina, as well as the a. alveolaris superior posterior). The maxillary sinus is supplied in particular abundance through the vessels extending from the a. maxillaris interna (8th branch of the a. carotis externa), the aa. alveolares superiores posteriores, the aa. alveolares superiores anteriores (from the a. infraorbitalis), the aa. nasales posteriores laterales (a. sphenopalatina), the a. palatina descendens (directly from the a. maxillaris interna). The ethmoid labyrinth is supplied through the anterior and posterior ethmoidal arteries from the a. ophthalmica which is the only branch of the internal carotid artery leading from the cranial cavity. The anterior ethmoidal artery (a. ethmoidalis anterior) penetrates through the corresponding foramen in the medial wall of the orbit, then through an opening in the cribriform plate into the cranial cavity where it gives off the anterior meningeal artery (a. meningea anterior) to the dura mater. Thence it passes, together with the ethmoidal nerve, through the anterior orifice of the above-mentioned plate into the nasal cavity, to supply the anterior cells of the ethmoid bone. The posterior ethmoid artery enters into the foramen ethmoidale posterior of the papyraceous lamina and reaches the posterior cells of the ethmoid bone.

The ethmoid labyrinth is also supplied with blood from the aa. nasales posteriores laterales (from the system of the external carotid artery).

The frontal sinus is supplied from the aa. nasales posteriores, as well as from the branches of the a. ophthalmica (in particular from the aa. ethmoidales). The sphenoid sinus is supplied not only by the aa. nasales posteriores, the a. pterygopalatina and the a. Vidiana, but also receives arterial blood from the branches of the dura mater.

The above information is not enough for a comprehensive picture of arterial supply to the paranasal sinuses, since the latter also receive blood from anastomoses: the system of the internal carotid artery communicates with that of the external carotid artery through the a. angularis (from the a. maxillaris externa, the branches of the a. carotis externa), and with the a. dorsalis nasi (from the a. ophthalmica, the branches of the a. carotis internae). In addition, the branches of the a. maxillaris interna communicate in the following manner: the a. ethmoidales anterior with the a. ethmoidales posterior, the latter with the a. nasalis posterior, and the a. nasopalatina with the a. palatina major.

The material given above shows that the arterial supply of the paranasal sinuses and that of the orbits have very much in common.

The venous network of the paranasal sinuses is likewise closely connected both with the veins of the eye and those of the face, nasopharynx and meninges.

Venous blood from the maxillary sinus is drained into the infraorbital and supraorbital veins, as well as into the plexus lacrimalis (through the v. angularis). In addition, the veins of the maxillary sinus communicate with the plexus pterygoideus, the veins of the face and the sphenoid sinus.

The fact that the anterior and superior ethmoidal veins empty into the supraorbital vein, communicate not only with the veins of the orbit but also with the veins of the dura mater and sometimes drain directly into the cavernous sinus is of considerable interest clinically. The vv. perforantes of the frontal sinus communicate with the veins of the dura mater; the veins of the frontal sinus with the v. ophthalmica and the v. supraorbitalis; the v. diploica with the v. frontalis and the superior longitudinal sinus. The veins of the sphenoid sinus communicate with the veins of the sphenoid plexus and drain into the cavernous sinus.

These facts concerning the arterial supply to and venous drainage from paranasal sinuses help explain the nature of complications in the eyes, orbits, meninges and paranasal sinuses observed in clinical conditions.

The lymphatic vessels issuing from most of the paranasal sinuses lead to the retropharyngeal, deep cervical and submaxillary glands, as well as to the lymphatic vessels of the face. According to L. N. Pressman, the intraadventitial and perivascular spaces in the posterior bony wall of the frontal sinus together with the perineural spaces connect the frontal sinus with the cranial cavity.

The innervation of the paranasal sinuses by sensory fibres is effected through the lst and 2nd branches of the trigeminal nerve. The nn. ethmoidales anterior and posterior, as well as the nn. nasales (mediales, laterales and externi) take their origin from the 1st branch—the n. ophthalmicus (specifically, from its branch—the n. nasociliaris). The 2nd branch (n. maxillaris) gives off the n. infraorbitalis (with its branches—the nn. alveolares superiores), as if the latter were an extension of the basic trunk, as well as the sphenopalatine nerves—the nn. sphenopalatini. The anterior ethmoidal nerve passes through its namesake opening in the orbit into the cranial cavity, from where it continues through an opening in the cribriform plate of the ethmoid bone into the nasal cavity, to innervate the mucous membrane of the anterior ethmoid cells and the frontal sinus.

The posterior ethmoidal nerve passes through the corresponding foramen to innervate the posterior ethmoid cells and the sphenoid sinus.

The maxillary sinus is innervated by the superior alveolar nerves (nn. alveolares superiores) leading from the lst branch of the trigeminal nerve.

The ethmoid labyrinth is innervated in its anterior portion by the anterior ethmoidal nerve and in its posterior portions by the posterior ethmoidal and nasal nerves (from the lst and 2nd branches of the trigeminal nerve), as well as by the sphenopalatine ganglion.

The nerve supply to the frontal sinus is through the anterior ethmoidal nerve, as well as through a branch of the n. supraorbitalis from the n. frontalis.

The sympathetic nerve fibres come to the paranasal sinuses from the plexus caroticus through the ganglion sphenopalatinum.

As noted above, the peripheral nerve endings of the olfactory analysor originate from the cells of the olfactory epithelium located in the upper portion of the nasal septum, as well as over the internal surface of the superior and partly of the middle nasal turbinate. The stimulation is conveyed through the fila olfactoria to the olfactory bulb in the cranial cavity, thence to the subcortical olfactory centres through the tractus olfactorius and the trigonum olfactorium, to the grey substance and farther to the pyramidal cells of the cortex of the gyrus Hippocampi through the pedunculus septi pellucidi, the anterior end of which, according to Ferreri, is the centre of olfaction.

THE ORBIT

The orbit is a cavity with an entrance of an irregular round form (see Fig. 4). The orbital edges forming the entrance are the most compact portions of its bony walls. The superior and infero-external margins are particularly hard. The corners of the orbital margins are round, and immediately beyond them the cavity begins to narrow, then widens over a certain extent and narrows again farther on. The narrowest section is the orbital apex near the optic foramen (see Fig. 1*j*).

The orbit is formed by several cranial bones, which serve simultaneously as the boundary walls of the adjacent regions, i.e., the paranasal sinuses and the cranial cavity.

The superior wall (see Fig. 4*a*) separates the orbit from the anterior cranial fossa and from the frontal sinus. If considerably developed, the latter may spread as far as the external edge of the orbit, and posteriorly—to the lesser wing of the sphenoid bone; in such cases the superior wall is almost completely used to form the floor of the frontal cavity, and then only a small section of the posterior portion of the orbit borders on the cranial cavity. In the anterior portion the superior wall is formed by the orbital part of the frontal bone, and in the posterior portion—by the lesser wing of the sphenoid bone (see Fig. 4*e*); it is dome-shaped, particularly in the anterior portion.

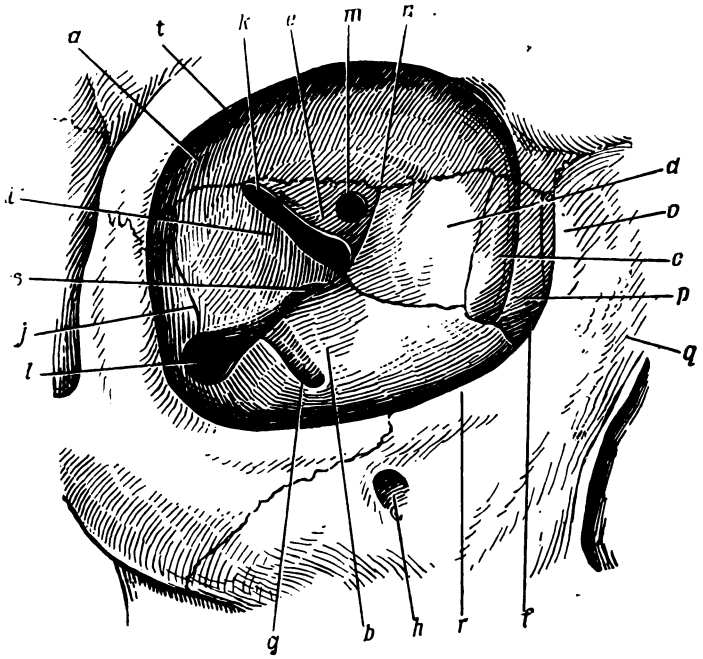


Fig. 4. Entrance to the orbit (after V. P. Vorobyov)

a—roof of the orbit (orbital surface of the frontal bone); *b*—floor of the orbit (orbital surface of the maxillary bone; *c*—lacrimal bone; *d*—papyraceous lamina; *e*—lesser wing of the sphenoid bone; *f*—lacrimal sac fossa; *g*—infraorbital groove; *h*—infraorbital foramen; *i*—orbital surface of the great wing of the sphenoid bone (part of the external orbital floor); *j*—orbital surface of the malar bone; *k*—supraorbital fissure; *l*—infraorbital fissure; *m*—optic foramen; *n*—posterior ethmoid orifice; *o*—crista lacrimalis anterior; *p*—crista lacrimalis posterior; *q*—nasal bone; *r*—infraorbital boundary; *s*—foramen rotundum; *t*—supraorbital boundary

At the anterior margin of the superior wall there are two depressions. The one in the external part is the lacrimal fossa (fossa glandulae lacrimalis), lodging the lacrimal gland. The other depression, the fovea trochlearis, and the trochlear spine (spina trochlearis) lie on the border between the superior and internal walls, some 4 to 5 cm from the margin. In this portion the body of the superior oblique muscle transforms into a tendon and slips through the tendinous, or cartilaginous, ring of the trochlea attached to the fovea or spina trochlearis. Along its further length the superior wall is smooth, and is joined by a barely visible seam to the lesser wing of the sphenoid bone.

The superior wall is very thin, especially where it forms the floor of the frontal sinus. The bony substance of the superior wall disappears, particularly in old age, as a result of which only the periosteum remains to separate the orbit from the cranial cavity.

The superior wall is continuous with the internal and external walls, without any marked borderline.

The internal wall (see Fig. 5), very thin and flat, is placed almost vertically, save for an occasionally observed slight prominence to the orbital side.

In its anterior part the internal wall is formed by the lacrimal bone, which is linked by a smooth seam (see Fig. 5*o*) to the papyraceous lamina of the ethmoid bone; the latter (see Fig. 5*a*) adheres to the lateral surface of the body of the sphenoid bone, a small part of which (namely, the lesser wings) is incorporated in the internal wall (see Fig. 5*p*).

The papyraceous lamina (see Fig. 5*a*) forms most of the internal wall of the orbit. It separates the latter from the ethmoid cells, and is the thinnest of all the walls of the orbit.

The anterior part of the internal wall, the lacrimal bone, 3 to 4 mm wide, is convex to the nasal side and has a depression—the lacrimal sac fossa (fossa sacci lacrimalis; see Figs. 4*f* and 5*q*). Anteriorly and posteriorly, the fossa is limited by protruding edges of crests; it becomes flatter as it rises, and deeper as it descends and merges into the nasolacrimal duct.

The medial margin of the orbit is formed by the frontal process of the superior maxillary bone (crista lacrimalis anterior) which limits the lacrimal sac fossa anteriorly and constitutes part of its floor.

The inferior end of the posterior crest (crista lacrimalis posterior; see Figs. 4*p* and 5*i*) is shaped like a hook (hamulus lacrimalis) and narrows the entrance to the nasolacrimal duct.

The internal wall contains the anterior and posterior ethmoid foramina (see Fig. 5) transmitting the corresponding arteries, veins and nerves.

The inferior wall of the orbit (see Fig. 4*b*) is triangular in shape; it is formed by the orbital surface of the superior maxillary bone; the apex of the triangle is formed by the orbital process of the palate bone, while the external portion of the inferior wall is the orbital surface of the malar bone. The inferior wall gradually merges into the internal wall with which it is connected by a smooth suture. It is linked only to the anterior portion of the external wall.

In the inferior wall there is a depression—the infraorbital groove (sulcus infraorbitalis; see Fig. 4*g*)—which begins at the infraorbital fissure and passes from behind forward. At first the groove is covered with a connective tissue membrane, which turns into bone and forms a canal (canalis infraorbitalis) ending with an opening (foramen infraorbitale; Fig. 4*h*) in the anterior wall of the superior maxillary bone, 4 mm below the orbital margin (see Fig. 86). This canal transmits the infraorbital nerve, artery and vein.

The external wall is the thickest of all the orbital walls; it separates the orbit from the subtemporal fossa, and is formed by the great wing of the sphenoid bone (see Fig. 4*i*) and the malar bone (see Fig. 4*j*). The wall is smooth; only in its posterior portion, on the

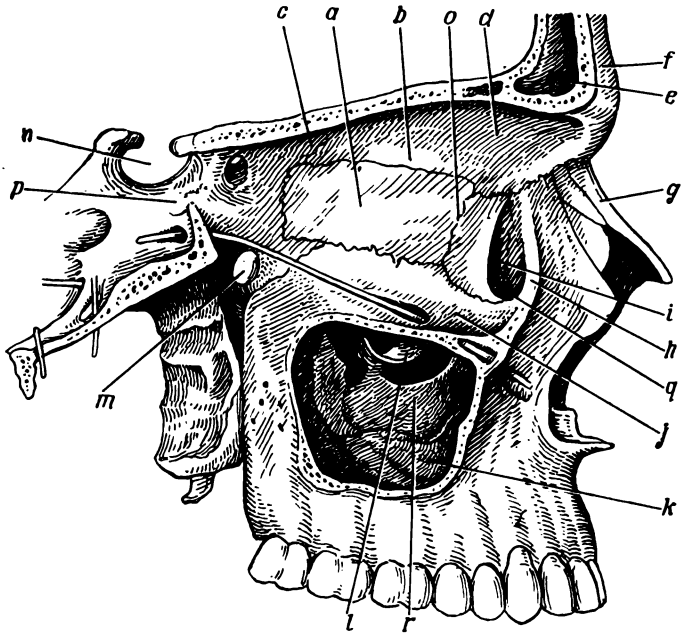


Fig. 5. Internal wall of the orbit (after V. P. Vorobyov)

a—papyraceous lamina; *b*—anterior ethmoid orifice; *c*—posterior ethmoid orifice; *d*—orbital surface of the frontal bone; *e*—frontal sinus; *f*—glabella; *g*—nasal bone; *h*—crista lacrimalis anterior; *i*—crista lacrimalis posterior; *j*—facial wall of the superior maxillary bone; *k*—maxillary sinus; *l*—processus uncinatus; *m*—foramen sphenopalatinum; *n*—Turkish saddle; *o*—suture between the lacrimal bone and papyraceous lamina; *p*—body of the sphenoid bone; *q*—lacrimal sac fossa; *r*—internal wall of the maxillary sinus

orbital surface of the great wing of the sphenoid bone, near the fissura orbitalis superior does it have a small prominence—the spina musculi recti lateralis—to which one of the heads of the rectus externus is attached.

The bony walls of the orbit have fissures and openings to transmit vessels and nerves.

The supraorbital fissure (fissura orbitalis superior) lies between the lesser and great wings of the sphenoid bone (see Fig. 4*к*). It varies extensively in width and transmits all the nerves supplying stimuli to the eyeball, namely, the oculomotor, the trochlear and the abducens, the first branch of the trigeminal nerve and the superior ophthalmic vein. This fissure connects the orbit with the middle cranial fossa—a fact which determines its great role in the pathology of the eye. A number of processes occurring in the region of the fissure may provoke the so-called supraorbital fissure syndrome.

The infraorbital fissure (fissura orbitalis inferior, see Fig. 4*l*) connects the orbit with the sphenopalatine and subtemporal fossae. It is formed by the inferior wall of the orbit, the great wing of the sphenoid bone and sometimes by the malar bone as well.

The facial nerve canal begins at the apex of the orbit; its average length is 8 to 9 mm, the width is 5 to 6 mm; the aperture in the orbit

is somewhat wider than that in the skull, as a result of which the canal is funnel-shaped.

Apart from the orbital fissures and the optic foramen, the bony walls of the orbit have small apertures to transmit the vessels and nerves connecting the orbit with the adjacent regions.

The bony walls of the orbit are lined with a very thin periosteum which is loosely adherent to the underlying bone, save for the regions of the sutures. The periosteum adheres very tightly to the bony margins of the orbit. In the superior and inferior orbital fissures it forms a dense fibre network resembling a membrane with openings to transmit vessels and nerves.

Owing to its loose accretion with the underlying bone, the periosteum easily peels off, which contributes to the development of a pathological process.

The orbital contents. The orbital cavity contains the eyeball, muscles, vessels and nerves, the ligaments and fat and cellular tissue.

The position of the eyeball in the orbital cavity also depends on the quantity of fat and cellular tissue which constitutes a sort of lining and simultaneously serves to protect it against sudden backward displacement; in case of a hard blow, for example, the fat and cellular tissue acts as a shock-absorber and prevents the eyeball from being knocked against the bony orbital walls. This tissue also serves to protect the vessels and nerves, which can be easily displaced, and thus prevents their disruption in traumatic lesions of the orbit.

The tarso-orbital fascia (fascia tarso-orbitalis) is a rather thin but relatively solid lamina of connective tissue whose fibre bundles are interwoven with the anterior surface of the eyelid cartilages, with which they form a single whole.

Together with the cartilages the tarso-orbital fascia adheres to the periosteum all along the orbital margin to form a kind of a diaphragm (anterior, or fifth, wall of the orbit) which closes the entrance to the orbit (septum orbitae) and may contribute to the extension of various morbid processes occurring in the orbit. Thus, the clinical picture varies extensively in relation to the site of origin of the morbid process in the bone, i.e., in front of or behind the tarso-orbital fascia. A tumour growing in the orbit frequently encounters considerable resistance from the fascia, which may for a long time swell under pressure from the newgrowth but resist its outward penetration.

The vascular system of the orbit and eyeball. The organ of vision is supplied with arterial blood from the internal carotid artery; only the eyelids are supplied by vessels branching off from the external carotid artery. The arteries of the orbit are very thin, meandering, and loosely connected with its cellular tissue from which they can be easily separated.

The principal branch of the internal carotid artery is the ophthalmic artery (a. ophthalmica), which supplies arterial blood to the eye. It branches off from the fourth bend of the internal carotid artery, outwardly from the anterior sphenoid process; here it passes directly into the optic nerve canal, where it lies above the nerve, now on the inner, now on the outer side. The ophthalmic artery is separated from the optic nerve by the dura mater. In rare cases it is lodged in its own bony canal. Passing through the optic nerve canal, the artery gives off thin branches to the optic nerve sheath, the optic nerve proper and the periosteum. The artery penetrates into the orbit between the abducens nerve and the rectus externus muscle; here it passes outwardly from the optic nerve but soon turns inward, intersects the optic nerve and passes above it next to the internal wall of the orbit. Farther on it passes obliquely from behind forwards and gives off most of its branches under the inferior rectus muscle.

One of the branches of the ophthalmic artery—the central retinal artery (a. centralis retinae)—plays the main role in the arterial supply of the eye. It penetrates through the meninges into the optic nerve trunk and gives off branches to the nerve fibres on its way. Sometimes this artery takes its origin from the trunk of the ciliary artery (more generally from the internal) and penetrates into the optic nerve from below.

The branches of the ophthalmic artery which are common for the orbit and paranasal sinuses are the superior branch (a. frontalis) which passes through the incisura supraorbitalis and supplies the forehead skin and muscles as the supraorbital artery (a. supraorbitalis); the inferior branch (a. dorsalis) which supplies the lateral nasal walls and the glabella region and by communication with the a. angularis connects the internal and external carotid arteries.

The veins of the orbit. The principal venous trunk of the orbit is the superior ophthalmic vein (v. ophthalmica superior) which passes along the border between the superior and internal walls of the orbit and lies between the superior oblique muscle and the internal palpebral ligament. In the depth of the orbit, the main trunk passes under the inferior rectus muscle backwards and outwards, intersects the optic nerve, then continues between the superior and external rectus muscles and penetrates into the cavernous sinus through the supraorbital fissure.

According to V. P. Vorobyov, the superior ophthalmic vein receives (a) the supraorbital vein (v. supraorbitalis); (b) the nasofrontal vein (v. nasofrontalis) which extensively communicates with the v. angularis, a branch of the anterior facial vein (these two veins drain blood from the nasofrontal region); (c) the anterior and posterior ethmoidal veins (vv. ethmoidales anterior and posterior) draining blood from the region supplied by the corresponding arteries; (d) the lacrimal vein (v. lacrimalis) draining blood from

the lacrimal gland and the external rectus muscle of the eye; (e) the muscular veins (vv. musculares) draining blood from the superior and external rectus muscles of the eye; (f) the palpebral veins (vv. palpebrales); (g) the anterior and posterior conjunctival veins (vv. conjunctivales anterior and posterior).

The superior ophthalmic vein also receives the veins leading from the eyeball: (a) the central retinal vein (v. centralis retinae) which passes through the optic nerve trunk together with the corresponding artery; (b) the anterior and posterior ciliary veins (vv. ciliares anteriores and posteriores); (c) the vorticose veins (vv. vorticosae) from the choroid (vascular tunic of the eye); (d) the episcleral veins (vv. episclerales).

The superior ophthalmic vein communicates with all the veins of the orbit and receives especially numerous branches in its middle part where, as a consequence, it becomes spindle-shaped.

The venous blood from the inferior portion of the orbit is collected in the inferior ophthalmic vein (v. ophthalmica inferior) which in turn drains into the superior ophthalmic vein and sometimes directly into the cavernous sinus.

Apart from the superior ophthalmic vein, the inferior ophthalmic vein communicates with the pterygoid plexus (plexus pterygoideus) and the infraorbital vein (v. infraorbitalis).

In this way, both ophthalmic veins communicate with the veins of the frontal and facial regions, the paranasal sinuses, the cranial bones and the sinuses of the dura mater.

The lymphatic system of the orbit. The presence of lymphatic vessels in the orbit is not denied by most specialists (Averbach, Birch-Hirschfeld). Thus, Birch-Hirschfeld discovered in the orbital cellular tissue a system of fissures which in his opinion must be regarded as the beginning of a lymphatic system communicating with the lymphatic system of the nose (through vessels of the ethmoid labyrinth and the nasolacrimal duct). Some authors presume that lymph drainage from the eyeball is carried out through the suprachoroid and Tenon's spaces. The latter communicates with the intervaginal space of the optic nerve to provide communication between the eyeball and the cranial cavity.

The nerve supply of the orbit and eyeball. The orbit contains the optic nerve, the motor nerves of the ocular muscles, the branches of the trigeminal nerve, which is the sensory nerve, and the branches of the sympathetic nerves extending from the cervical plexus of the internal carotid artery and from the plexus of the cavernous sinus.

The optic nerve. From the eyeball the optic nerve leads to the apex of the orbit, the optic foramen (see Fig. 4*m*). Inside the orbit, the nerve is S-shaped, owing to which it is not subject to strong tension during movements of the eyeball and in the presence of pathological processes in the orbit leading to forward displacement of the eyeball, and its fibres do not suffer injury.

Fig. 8. X-ray film of the paranasal sinuses and orbits in the anterior sagitt projection

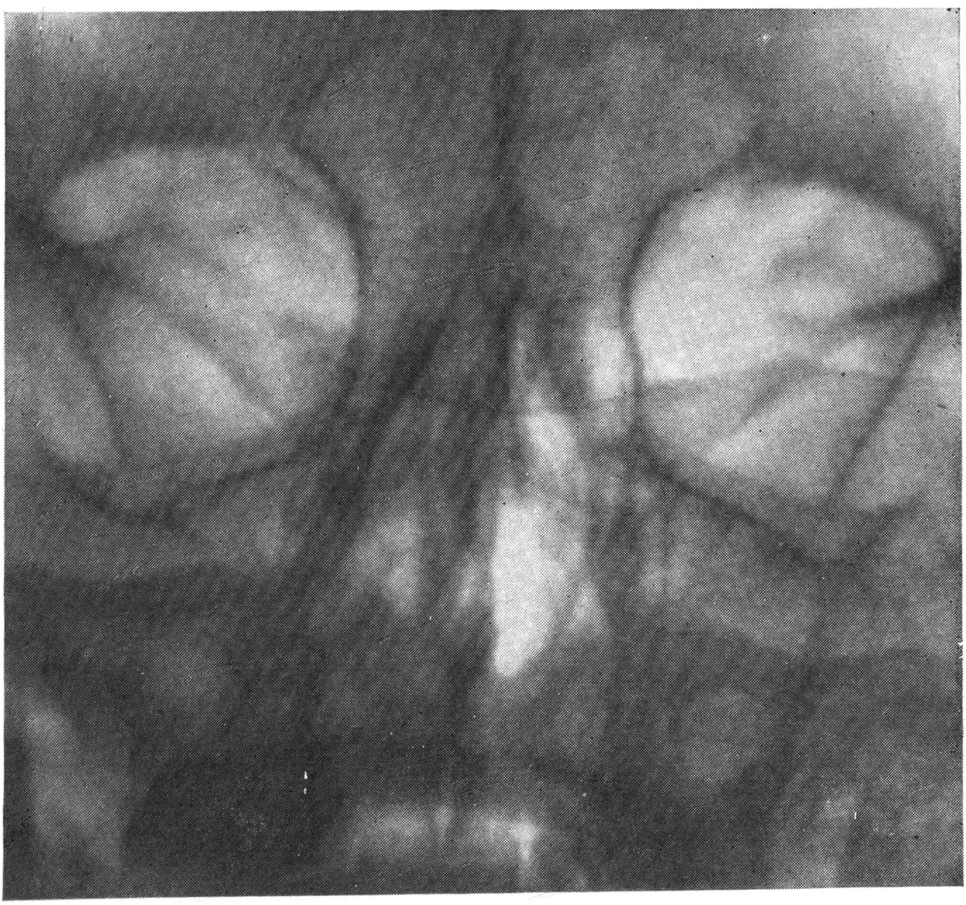


Fig. 9. X-ray film of the orbits and paranasal sinuses in the anterior semiaxial projection

Fig. 10. X-ray film of the optic foramen

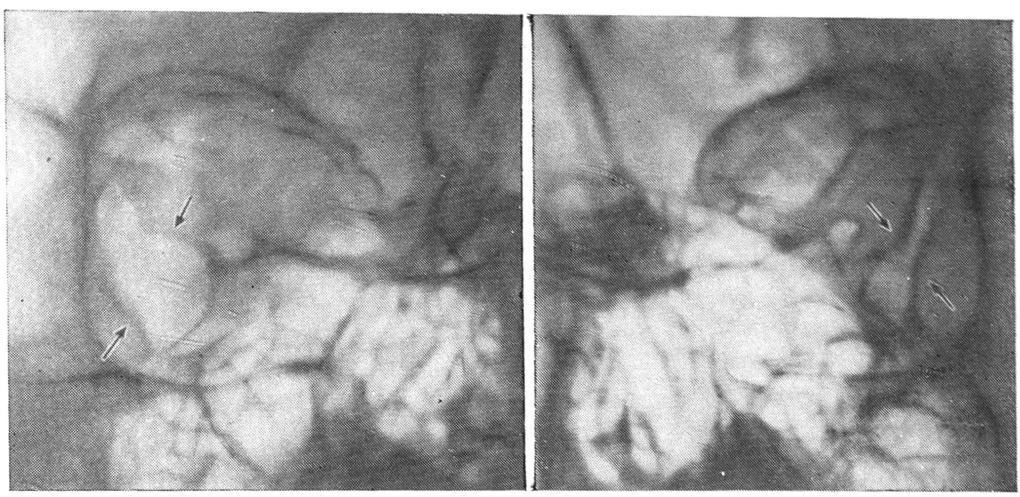


Fig. 11. X-ray film of the orbits. Supraorbital fissures are well differentiated (see arrows); the supraorbital fissure at right is markedly dilated

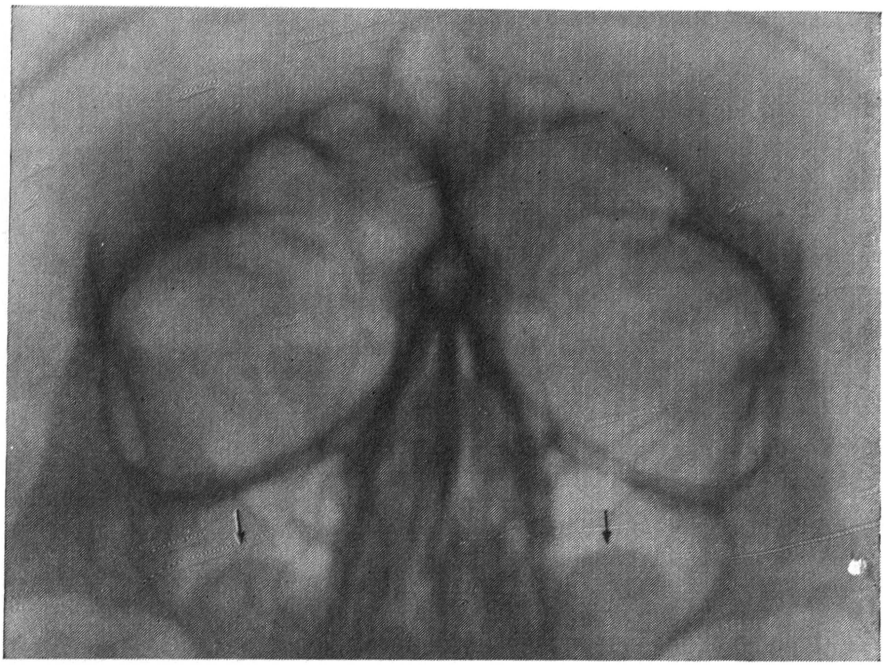


Fig. 12. Semicircular shadows in the maxillary sinuses (cyst?)

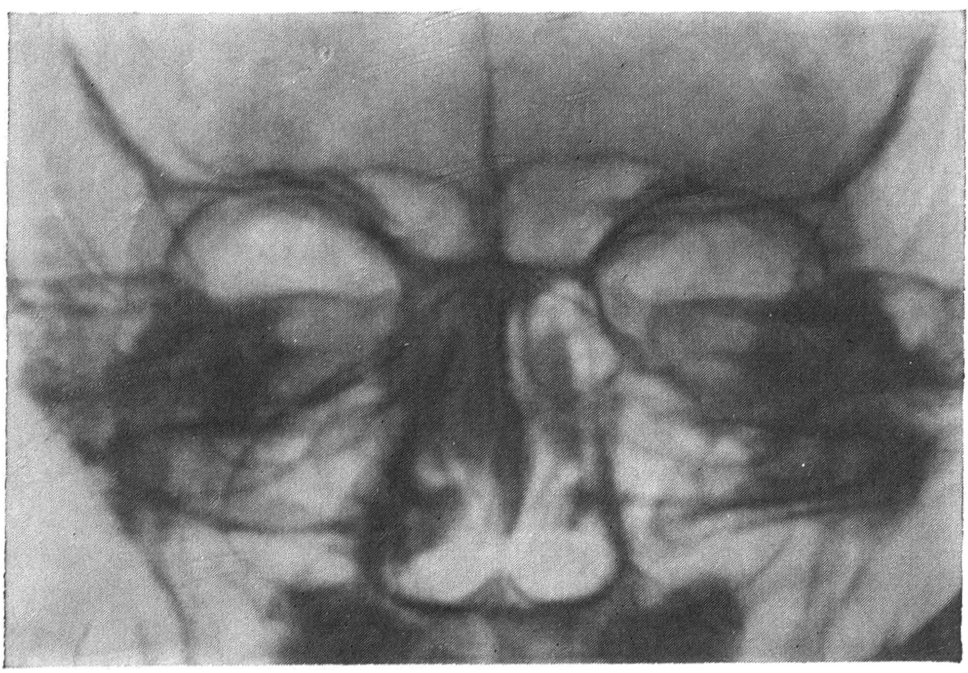


Fig. 13. Right-side ethmoiditis

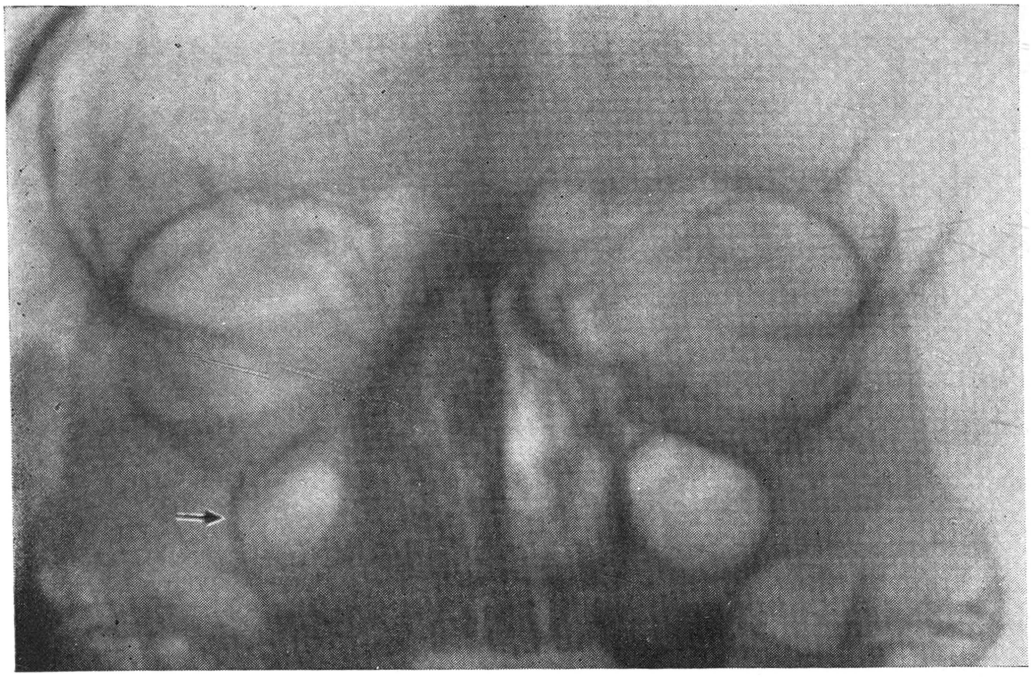


Fig. 14. Perimural shadows in the right-side maxillary sinus (see arrow)

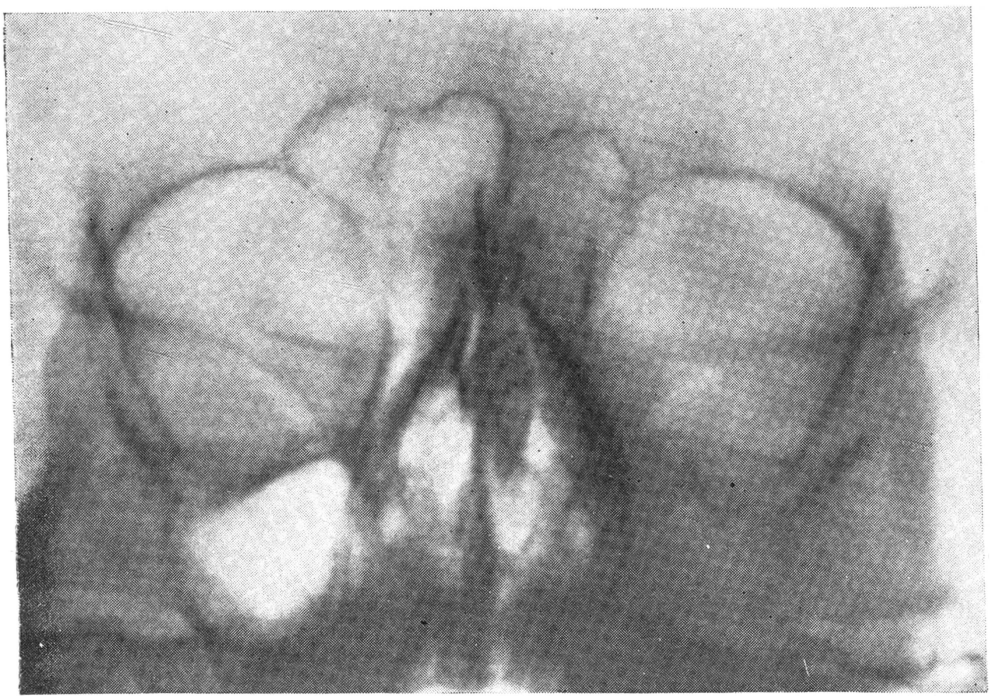


Fig. 15. Left-side hemipansinusitis. Shadowing of the frontal, ethmoid and maxillary sinuses at left; the left orbit is dim. Clinical signs of a phlegmon in the left orbit

The optic nerve has three sheaths, which are an extension of the meninges. The external sheath of the eyeball merges into the sclera and forms its periosteum in the optic nerve canal. This sheath is adjoined by a thin membrane extending from the pia mater. The space between them serves for lymph flow to the lymphatic fissures of the meninges. From the orbit the optic nerve penetrates into the cranial cavity through the corresponding canal, where it is lodged precariously, since it is surrounded by insufficiently pliant bony walls and is liable to injury when these walls are damaged. It will be recalled that the canal walls lie in close proximity to the sphenoid sinus and the posterior ethmoid cells from which the optic nerve is separated by a very thin plate; sometimes it lies loosely in the sphenoid sinus.

The motor nerves of the orbit, namely, the motor oculi, the trochlear and the abducens, innervate the eye muscles.

The oculomotor nerve (n. oculomotorius—3rd pair) provides nerve supply to the following muscles of the eyeball: the internal, superior and inferior rectus muscles, the obliquus inferior, the superior palpebral levator, the pupillary sphincter and the ciliary muscle. Its fibres take their origin from the nuclei in the grey substance of the brain, under the Sylvian aqueduct, on a level with the superior tubers of the corpora quadrigemina. The fibres leading from the nuclei form on the brain base a single trunk, which extends forward, penetrates the dura mater and the posterior wall of the cavernous sinus, where it lies in the depth of its external wall under the trochlear nerve. Through the supraorbital fissure the optic nerve penetrates into the orbit where it pierces Zinn's tendinous ring and gives off branches to the appropriate muscles.

The initial part of the external inferior branch (r. inferior) of the oculomotor nerve, the longest of its three branches, which passes along the inferior rectus muscle to the obliquus inferior, gives off a short root of the ciliary ganglion (radix brevis ganglii ciliaris) which interweaves with the posterior polus of the ciliary ganglion from below.

The oculomotor nerve is connected with the sympathetic branches from the cavernous plexus (plexus cavernosus) and the sensory roots from the ophthalmic nerve.

The trochlear nerve (n. trochlearis—4th pair). The nucleus of this nerve is located under the Sylvian aqueduct beside the nuclei of the motor oculi on a level with the inferior tubers of the corpora quadrigemina. Following intersection with the nerve on the opposite side in the region of the anterior velum, the trochlear nerve follows forward from its nucleus to the brain base where it pierces—as does the oculomotor nerve—the posterior wall of the cavernous sinus. Farther on it passes in its external wall between the oculomotor and ophthalmic nerves and penetrates into the orbit through the supraorbital fissure outside Zinn's tendinous ring, to ramify in the obliquus

superior muscle of the eyeball. The trochlear nerve receives sympathetic fibres from the cavernous plexus and the sensory fibres—from the ophthalmic nerve.

The abducens nerve (n. abducens—6th pair). The nucleus of the nerve lies in the grey substance of the fossa rhomboides in the tegmentum of the bridge of Varolius. From the nucleus it passes through the bridge of Varolius to the brain base where it pierces the dura mater and penetrates into the cavernous sinus. Here it lies between the internal carotid artery and the ophthalmic nerve under the oculomotor and trochlear nerves, pierces then the anterior wall of the cavernous sinus, penetrates into the orbit through the supraorbital fissure and ramifies in the rectus externus muscle.

The sensory fibres are supplied to the eyeball by the lst branch of the trigeminal nerve. The ophthalmic nerve extends from the Gasserian ganglion forwards and penetrates into the cavernous sinus where it lies in the external wall, under the trochlear nerve. In the sinus, it receives sympathetic fibres from the plexus of the cavernous sinus. Before passing through the supraorbital fissure the n. ophthalmicus ramifies into three branches: (1) the nasociliary (n. nasociliaris), (2) the supraorbital (n. supraorbitalis) and (3) the lacrimal (n. lacrimalis). These branches supply sensory fibres to the eyeball, eyelids, lacrimal sac and lacrimal gland. The supraorbital nerve supplies sensory fibres to the skin of the forehead and the hairy part of the head up to the temporal and sincipital regions.

Special mention should be made of the branches of the nasociliary nerve. In the orbit it divides into (1) three or four long ciliary nerves (nn. ciliares longi) which innervate the vascular tunic (choroid) and cornea and communicate with the short ciliary nerves (nn. ciliares breves) and (2) the anterior and posterior ethmoidal nerves, which have already been described in this chapter. The fact that the nasociliary nerve supplies fibres to the eye, the region of the nose and its accessory sinuses is of great practical value.

The motor and sensory nerves of the eye are connected with the sympathetic nervous system through the ciliary ganglion, which lies in the orbit under the rectus externus muscle and adjoins the external periphery of the optic nerve beside the optic foramen, some 7 to 8 cm behind the eyeball. The ciliary ganglion receives motor fibres from the inferior root of the motor oculi nerve (radix brevis).

The ciliary ganglion is connected through the radix longa with the nasociliary nerve—a branch of the ophthalmic nerve containing sensory fibres—while 3 to 6 thin nerve fibres (nn. ciliares breves) connect it to the eyeball. These fibres lying along the route of the optic nerve pierce the adjacent sclera and ramify within the eyeball between the sclera and the choroid primarily in the vascular tract (iris, ciliary body, choroid proper). On their way to the eye past the ciliary ganglion, the short ciliary fibres receive sympathetic

fibres from the plexus of the internal carotid artery (innervation of the dilator pupillae). The short ciliary nerves supply stimuli to the ciliary muscle and the sphincter pupillae. The eyeball also receives nerve fibres directly from the trunk of the nasociliary nerve: the long ciliary nerves, which are the sensory fibres of the cornea, penetrate past the ciliary ganglion through the sclera in the vicinity of the optic nerve. In the region of the ciliary body, as well as along the circumference of the sclera, these nerves form with the short ciliary nerves a dense plexus which lies anteriorly to Schlemm's canal. In the orbit, where the branches of this plexus penetrate, they serve as sensory, as well as trophic, nerves.

The inferior portion of the orbit is supplied with sensory nerve fibres leading from the 2nd branch of the trigeminal nerve—the maxillary nerve, which escapes from the cranial cavity through the foramen rotundum, enters the sphenopalatine fossa, wherefrom it penetrates into the orbit through the infraorbital fissure. Here it follows the infraorbital groove, then the infraorbital canal, and escapes outside through the foramen infraorbitale as the infraorbital nerve. The maxillary nerve connects the orbit with the nasal cavity through the orbital branches (rr. orbitales). These nerves penetrate into the orbit through the infraorbital fissure and escape from it through the posterior ethmoid foramen to reach the mucosa of the posterior ethmoid cells and the sphenoid sinus, where they ramify.

In conclusion, it should be pointed out that the nuclei of the oculomotor nerves are connected with the cerebral hemispheres.

The cortical centres directing eye movements are in the posterior portion of the second frontal convolution.

THE LACRIMAL PASSAGES

The lacrimal apparatus has two departments: one with the function of tear secretion by the lacrimal gland situated in the superoexterior portion of the orbit; the other with the function of tear conveyance, or drainage, by the route which includes the lacrimal puncta, lacrimal canaliculi, lacrimal sac and nasolacrimal duct.

The lacrimal gland (glandula lacrimalis) is a complex tubuloracemose gland which is lodged in the anterior portion of the exterosuperior part of the orbit, in a depression of the frontal bone (fossa glandulae lacrimalis), and is divided into two unequal parts: the larger—superior (orbital) and the lesser—inferior (palpebral). The lacrimal ducts of both parts open out in the external portion of the superior arch of the conjunctiva. Tear secretion conveyed to the conjunctival sac moistens the eyeball and flows down to the outer angle of the eye through a lacrimal sulcus formed by the posterior margin of the lower eyelid and the surface of the eye.

The lacrimal puncta (puncta lacrimalia) give origin to the lacrimal canaliculi and to the lacrimal passages on the upper and lower eyelids (superior and inferior lacrimal puncta) 6 to 6.5 mm anteriorly to the inner angle of the eye. The puncta are turned somewhat backward; they commonly gape and touch the eyeball. They are invisible without retraction of the eyelids, since they are submerged in the lacrimal lake.

N. Y. Pokhisov holds that the lacrimal passages begin from the lacrimal stream which empties into the lacrimal lake followed by the lacrimal canaliculi, etc.

The lacrimal canaliculi (canaliculi lacrimales) first pass vertically for 1.5 mm, then deviate to the median plane at an obtuse angle, assume a horizontal direction and fall into the lacrimal sac (on its lateral wall), on a level with and behind the internal palpebral ligament (ligamentum palpebrae mediale). Before emptying into the lacrimal sac, the canaliculi join in a common mouth; less frequently each canaliculus falls directly into the lacrimal sac.

The ampulla canaliculi lacrimalis is that portion of the vertical knee of the canaliculi where they turn to the horizontal, and where the funnel-shaped narrowing gives place to an expansion. The canaliculi vary from 6 to 10 or 14 mm in length and from 0.5 to 1.5 mm in width, with the inferior canaliculus being somewhat longer than the superior.

As mentioned above, tears from the lacrimal canaliculi are conveyed to the next portion of the lacrimal passages, namely, the lacrimal sac, thence flowing into the membranous nasolacrimal, or nasal, duct opening through the nasal outlet under the inferior nasal turbinate. The sac and the membranous nasal duct lying in the bony nasolacrimal canal are regarded as the vertical knee of the tear-draining route (Fig. 6).

The characteristics of the bony framework and the topographo-anatomical relationships of the latter two departments to the adjacent ethmoid labyrinth, frontal sinus, nasal cavity and also to the maxillary sinus are very important, since they play a role both in the pathogenesis of dacryocystitis in case of the process extending by contact to the lacrimal sac (for instance, from the ethmoid labyrinth, which is facilitated by the presence of dehiscences in the bony portion of the nasolacrimal duct) and in the selection of the most rational surgical approach in dacryocystorhinostomy and the opening of the paranasal sinuses.

In the study of the anatomical characteristics and patterns of topography of the lacrimal passages great credit is due to the Russian rhinologists L. I. Sverzhevsky and F. S. Bockstein.

Bockstein's classical work *Surgery of Lacrimal Passages*, largely devoted to the endonasal method of surgical treatment of dacryocystitis, is particularly valuable for its clinical data and conclusions based on a wealth of thorough anatomical investigations.

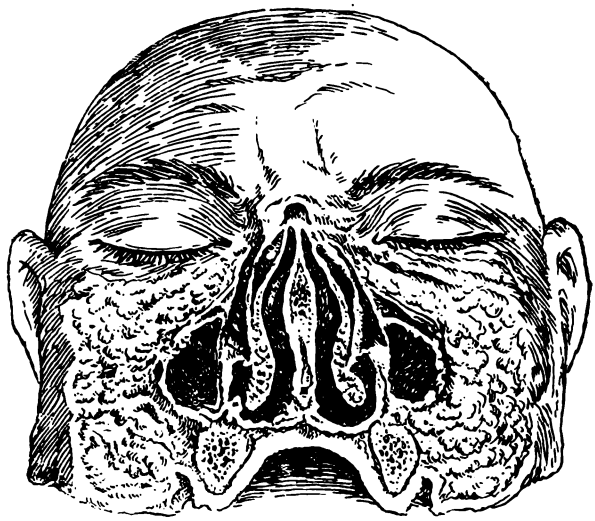


Fig. 6. Position of the lacrimal sac and nasolacrimal duct in relation to the lateral nasal wall and middle turbinate (after Polyak)

The lacrimal sac fossa (fossa sacci lacrimalis, Fig. 5) lodging the lacrimal sac is formed in the anterior portion by the frontal process of the maxilla and in the posterior portion by the lacrimal bone (Figs. 4*c*, and 7). The average size of the fossa according to F. S. Bockstein is as follows: diameter is 16 mm lengthwise and 8 mm across; the fossa is deepest in the inferior portion and becomes flat upwardly. Usually, both bones participate in equal measure in the formation of the lacrimal fossa. In some cases, however, either the frontal process or the lacrimal bone prevails. Cases where only one of these bones serves to form the lacrimal fossa are exceedingly rare.

On a macerated skull, the lacrimal fossa is distinctly bounded anteriorly by the ridge of the frontal process of the maxilla (crista lacrimalis anterior; Figs. 4*o*, 5*h*), easily felt with the finger on live tissue at the inner angle of the eye in outward retraction of the eyelids, and posteriorly—by the ridge of the lacrimal bone separating the lacrimal sac from the orbital cavity (see Figs. 4*p*, 5*i*)—the crista lacrimalis posterior.

The upper boundary of the lacrimal fossa is the junction (suture) of the frontal process of the maxilla and the lacrimal bone with the nasal process of the frontal bone.

With the lower ends of both ridges approximating, the lacrimal fossa narrows downwardly to turn into the bony nasolacrimal canal formed primarily by the maxillary bone, as well as by the lacrimal bone and the inferior nasal turbinate (see below).

The upper portion of the canal, situated in the body of the superior maxillary bone (more exactly, behind its frontal process on the inner surface), is in essence a groove restricted by two small bony eminences (eminentia lacrimalis) of the frontal process (sul-

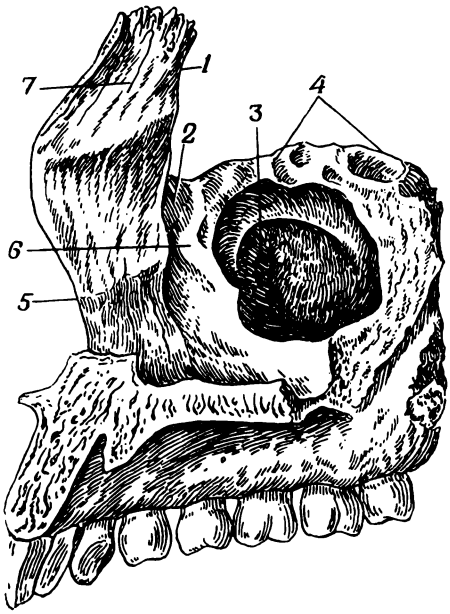


Fig. 7. Inside view of the right-side superior maxillary bone and the nasolacrimal duct (after V. P. Vorobyov)

1 — margo lacrimalis; *2* — sulcus lacrimalis; *3* — hiatus maxillaris; *4* — junction between the papyraceous lamina and the ethmoid bone; *5* — crista conchalis; *6* — lunula lacrimalis; *7* — processus frontalis

cus and lunula lacrimales) and the ridge of the anterior margin of the maxillary orifice (Fig. 7). The groove converts into a canal as a result of its being closed by the lacrimal bone in the upper portion and by the lacrimal process in the lower portion. The canal ends with a nasal outlet under the inferior nasal turbinate (Fig. 3*h*).

In some cases, the lacrimal bone takes no part in closing the groove; this is observed in cases where the above-mentioned bony eminences are marked and come so close together as to be in complete contact.

The length of the bony nasolacrimal canal does not exceed 10 to 12 mm, the width varying in different subjects between 2 and 8 mm (4 mm on the average), and its nasal outlet, which is generally round in shape, lies under the inferior nasal turbinate, in the so-called funnel of the inferior nasal meatus. The nasal outlet lies 15 to 20 mm from the nasal floor and 10 to 12 mm from the anterior margin of the inferior turbinate.

The nasolacrimal canal is often deeply lodged within the maxillary sinus as an eminence in the antero-superior portion of its internal wall (torus lacrimalis externus).

This eminence, which downwardly merges gradually into the convexity of the inferior nasal meatus, acquires great significance in the pathogenesis of suppurations in the lacrimal sac and nasolacrimal duct in the presence of a marked infraorbital recess (recessus infraorbitalis). In such cases, the recess continues forwards

from the torus lacrimalis externus into the frontal process of the maxilla, forming here the recessus praelacrimalis.

In the case of a considerable upward growth of the prelacrimal recess, as is seen in large maxillary sinuses and with a perpendicular position of the facial wall forming no depression in the region of the canine fossa, the pathological process can easily extend from the latter to the lacrimal passages.

The term torus lacrimalis internus is applied to the eminence of the frontal process, which contributes to the formation of the nasolacrimal canal and the lacrimal fossa and protrudes into the nasal cavity on the lateral nasal wall on a level with the middle nasal meatus.

In infants the bony nasolacrimal canal lies in front of the maxillary sinus which is underdeveloped and does not extend forward far enough to enclose the canal. In adults such structures are found only when the canal lies anteriorly to the maxillary sinus, directly under the facial surface of the maxillary bone. Such marked anatomical variants are usually combined with others: the lateral wall of the nasal cavity is noticeably indrawn into the maxillary sinus and its facial wall is markedly depressed.

Such are the basic elements of the relationships between the nasolacrimal canal and the maxillary sinus which plays a major part in its formation.

As to the relationship of the lacrimal fossa and the bony nasolacrimal canal to the ethmoid labyrinth, in nearly all cases (95 per cent of the preparations studied: 120 lacrimal fossae in 60 skulls) the superior and posterior parts of the lacrimal fossa, according to F. S. Bockstein, were found to be covered either by ethmoid cells, by the base of the processus uncinatus, by the place of attachment (pars fixa) of the middle turbinate, or, finally, by the cells of the agger nasi. Since these cells lie in direct contact with the medial wall of the lacrimal fossa, they are called the lacrimal cells. The antero-inferior part of the lacrimal fossa, or the region of the torus lacrimalis internus, was invariably free from ethmoid cells, according to the same author, and directly facing the nasal cavity. The only exception were cases where the above-mentioned sections of the lacrimal fossa and the torus lacrimalis internus were covered by the anterior margin of the middle turbinate. Dehiscences of the nasolacrimal canal also play a role in the pathogenesis of dacryocystitis caused by lesions of the neighbouring cells of the ethmoid labyrinth.

The frontal sinus reaches the lacrimal fossa only in isolated cases.

The nasolacrimal canal in most cases passes along the wall of the meatus nasi communis immediately in front and along the entire anterior margin of the middle turbinate and somewhat above it. In some cases, the canal and the lacrimal fossa are covered by the

middle turbinate: partially in 16 per cent of the cases and completely in 10 per cent, according to F. S. Bockstein. In his anatomical investigations F. S. Bockstein took note of other relationships of major importance in clinical practice (for example, in endonasal opening of the lacrimal sac); the fact is that in a few preparations the anterior end of the middle turbinate lay so far to the rear that the floor of the lacrimal fossa and the nasolacrimal canal were found to be 15 mm in front of this point. In other words, the processus uncinatus and the bulla ethmoidalis lay for the most part in front of, rather than behind, the middle turbinate, as is commonly the case. F. S. Bockstein also observed such relationships in his own surgical practice, mostly in atrophic processes in the nose. To reach the lacrimal sac in such cases the gouge should be placed, in his opinion, 2 to 2.5 cm anteriorly to the middle nasal turbinate.

The lacrimal fossa is lined with a thin periosteum. The cristae lacrimalis anterior and posterior are connected by means of a bridge-shaped fibrous lamina, which is a part of the periorbit; this lamina is connected with the lacrimal sac by loose cellular tissue. The lamina separates the lacrimal sac from the orbit.

The lacrimal sac (saccus lacrimalis) lodged within the lacrimal fossa measures 10 to 12 mm in length and 2 to 3 mm in width; the internal and external walls of the sac usually adjoin. The superior portion of the lacrimal sac ends in a blind vault, or cupola, and the inferior portion gradually merges into the nasolacrimal duct. There is often a narrowing (or "isthmus") on the border between the sac and the duct. This is the second physiological narrowing in the lacrimal passages (the first is at the point where the canaliculus falls into the lacrimal sac). The walls of the sac consist of three layers: (1) a stratified columnar epithelium, (2) a mucous membrane containing a great number of lymphatic cells collected in follicles and located within loose connective tissue, and (3) a dense fibrous layer of submucous tissue (middle layer) with numerous elastic fibres. The walls of the sac are interwoven with the fibres of the musculus orbitalis oculi whose contraction may help draw in tear secretion.

The lower half of the anterior wall of the lacrimal sac has scanty elastic tissue, which makes this portion the site of the greatest strain in case of congestion and the most convenient site of incision for phlegmons. The inferior part of the lacrimal sac may often contain a mucosal fold called the valvula lacrimalis which is a transient formation. In addition, there are a number of horizontal and vertical folds and eminences (trabeculae) all along the mucosa of the lacrimal sac.

The upper half of the anterior wall of the sac is the denser not only due to the great number of elastic fibres in the submucosa but also because the lacrimal sac is crossed at the superior pole by a dense fibrous ligament adherent to the wall (lig. palpebrae

mediale). This ligament is attached to the internal ends of the palpebral cartilages, to the frontal process of the maxilla (crista lacrimalis anterior) and, passing behind the lacrimal sac—to the crista lacrimalis posterior. The ligamentum palpebrae mediale can be felt with the finger at the inner angle of the eye with the eyelid drawn outwards. Palpation of the ligamentum palpebrae mediale helps to locate the upper border of the lacrimal sac and differentiate its diseases from frontitis or ethmoiditis.

The lacrimal sac is coated with the fibres of the musculus orbiculoris palpebrarum and the skin. It lies anteriorly to the septum orbitae attached to the crista lacrimalis posterior.

As noted above, the membranous nasal duct is a direct extension of the lacrimal sac, while the point where the sac transforms into the duct is defined as a physiological narrowing called the isthmus ductus nasolacrimalis, although it has the same width as the lacrimal sac, i.e., 3 mm on the average.

A torus formed by a thickened periosteum is sometimes found on the lateral wall of this region.

The membranous nasal duct begins to form in the sixth week of embryonal life in the following manner: an epithelial trabecula reaches into the depth of connective tissue from the orbital angle of the nasolacrimal fissure and subsequently becomes gradually detached from the primary epithelial cover of the face. By the 10th week the trabecula reaches the epithelium of the inferior nasal meatus, from which it is separated by a layer of connective tissue. The trabecula turns into a hollow, epithelium-lined duct in the eleventh week. At first the duct terminates with a blind end; it opens out into the lumen of the inferior nasal meatus in the 6th month of embryonal life.

As has been shown by Schwarz who performed 200 postmortem examinations of the newborn and fetuses beginning with the 3rd month of intrauterine life, the nasal outlet of the duct remains closed, i.e., blind, at birth in 35 per cent of the cases.

The length of the membranous nasal duct ranges from 10 to 24 mm, according to L. I. Sverzhevsky; in other words, it is 50 per cent longer on the average than the bony canal. In the newborn, the lumen of the canal is 1.5 to 2 mm in diameter; in adults it reaches 4 mm in the sagittal plane, while in the frontal plane it is somewhat less. In old age, the lumen of the canal widens considerably. Its internal surface is usually smooth. However, it may often have folds of a mucous membrane resembling venous valvulae and diverticula. Some of the folds may be large, such as Krauze-Berot's fold where the sac transforms into the canal and Hasner's valve at the nasal outlet.

As pointed out above, the membranous nasal duct terminates under the inferior nasal turbinate with an orifice called the nasal outlet, lying 1 to 10 mm from the anterior margin of the inferior

nasal turbinate. The distance between the nasal outlet and the floor of the nasal cavity is 8 to 23 mm. Rather than gape at the outlet the lumen of the duct usually appears shrunken owing to its medial wall consisting only of one layer—a mucous membrane. The form of the outlet is variable. Where the membranous outlet coincides with the bony outlet it is wide open. In other cases it takes the form of a horizontal or vertical fissure or a small, hardly noticeable round or oval orifice in the external wall of the inferior nasal meatus. The latter case is observed when the mouth of the membranous duct is located below the bony orifice. The location of the nasal outlet of the membranous nasal duct in relation to the bony nasal outlet is very important in the pathogenesis of dacryocystitis. The classification of anatomical variants of the structure of the nasal duct ends has been worked out by L. I. Sverzhevsky; the description of the four types he has established will be given in Chapter VI on the etiology and pathogenesis of dacryocystitis.

In the newborn, the outlet of the canal lies closer to the floor of the nasal cavity, and is less covered by the inferior nasal turbinate than in later years. In time the outlet shifts upwards from the floor of the nasal cavity and disappears under the arch of the inferior nasal turbinate.

Although the membranous nasal duct is rather closely connected with the periosteum of the bony canal, the space between them, particularly in the inferior portion, is filled with a thick venous network continuing from the cavernous tissue of the inferior nasal turbinate. The disorders in tear conveyance, which are seen in acute rhinitis, are due, in the light of the above-mentioned relationship between the nose and the nasal duct, to the fact that the primary swelling of the cavernous tissue of the inferior nasal turbinate is followed by a swelling of the cavernous tissue of the nasal duct, which leads to the narrowing of its lumen.

Passing obliquely from above downwards, backwards and somewhat aside (inwards), the duct forms a double arch-shaped bend, one convexity facing anteriorly, the other outwards. The duct passes at an angle of 70-82° open posteriory to the horizontal plane, whereas in the sagittal plane its direction corresponds to a line drawn between the middle of the internal palpebral ligament and the beginning of the nasolabial fold.

The duct lies in front of the anterior margin of the middle turbinate and somewhat higher. In rare cases, the duct with the lacrimal fossa is located far in front of the middle turbinate, or is covered by the latter. According to F. S. Bockstein, the posterior half of the lacrimal fossa and the entire lacrimal fossa are found to be covered by the ethmoid cells in 20 and 2 per cent of the cases respectively, these cells being encountered in the lacrimal sac region mostly in cases of a broad nasal structure and less frequently in narrow and high nasal structures.

Arterial blood is supplied through the a. ethmoidalis anterior (from a. ophthalmica) which gives off a branch leading along the nasolacrimal duct from the roots supplying the lateral part of the nose and the anterior portions of the nasal septum.

The veins of the nasal duct are linked with those of the inferior nasal meatus. The direct transformation of the cavernous plexus of the inferior nasal meatus into the analogous tissue of the mucosa of the nasal duct has already been described above.

The lacrimal gland is innervated by a branch leading from the n. lacrimalis, which in turn is a branch (r. ophthalmici) of the trigeminal nerve.

The secretory fibres of the lacrimal gland arise from the facial nerve, and the sympathetic fibres from the cervical plexus.

The close connection between the trigeminal nerve and the secretory fibres accounts for reflex lacrimation in irritation of the mucous membrane of the nose, cornea and conjunctiva.

The reflex arc, which transmits irritation from the nasal mucosa to the centres regulating tear secretion and then to the secretory routes of the n. lacrimalis to cause lacrimation, is fully within the scope of action of the trigeminal nerve alone (the sensory fibres of the nasal mucosa stem from the lst and 2nd branches of this nerve, and the secretory routes of the n. lacrimalis extend from its lst branch). The appearance of a series of reflexes in the nasal cavity attending the lacrimal reflex is due to the sensory fibres of the nasal cavity (from the trigeminal nerve through the ganglion sphenopalatinum) being connected with the sympathetic fibres of the plexus caroticus.

The pathological processes occurring in the lacrimal sac also serve as a source of the lacrimal gland reflex.

II

X-Ray Picture of the Orbito-Sinual Region

TECHNIQUES AND METHODS OF X-RAY EXAMINATION OF THE ORBIT AND PARANASAL SINUSES

Prior to the examination of the orbital region and paranasal sinuses, pictures of the whole skull should be taken in two and sometimes in three projections. Although these pictures will not reveal fine structural changes in the bony walls of the orbit and paranasal sinuses, they will still indicate the region deserving most attention. Sometimes individual parts of the orbit, such as the region of the supraorbital fissure, the optic nerve canal, etc., should be investigated and in case of changes in the paranasal sinuses, photographed in different projections.

The structure of the orbit complicates X-ray examination, since not all of its walls are distinctly seen in the X-ray film. With the head adjusted in a special position, however, and the central beam being sent in the appropriate direction, a distinct representation of individual parts of the orbit can well be achieved.

A major requirement of X-ray photography of the orbital region and paranasal sinuses is the correct position of the patient's head and accurate adjustment of the X-ray tube.

As has been noted before, pictures of orbits and paranasal sinuses should be taken in different projections, of which the most suitable are the anterior sagittal, the anterior semiaxial, the lateral and the axial.

The anterior sagittal projection (occipito-frontal direction of the central beam). The patient is laid forehead on the bolster so that the frontal plane of the skull is parallel and the sagittal— perpendicular to the cassette. The head is fixed with a broad bandage having sand bags on both ends. The central beam should pass through the occiput and the root of the nose. The X-ray picture (Fig. 8) will give a clear image of the upper half of the orbit with the markedly prominent supraorbital fissure and the lesser wing of the sphenoid bone, as well as the frontal sinuses; sometimes the sphenoid sinuses can also be seen.

The anterior semiaxial projection (Fig. 9). The patient's head is pressed against the cassette at the chin and nasal tip. The cen-

tral beam passes in the sagittal plane of the skull from the nape towards the chin. The shadow of the pyramid is thus thrown down to cover only the lower portion of the maxillary sinus—the region of the alveolar recess. The margins of the orbit, the superior and exterior walls, as well as a part of the inferior wall are seen clearly. The images of the lesser wing of the sphenoid bone and the supraorbital fissure are not quite distinct, and the infraorbital fissure is somewhat dim at the superointernal angle of the maxillary sinus. A round orifice (foramen rotundum) is to be found beneath it.

This picture will clearly show the external wall of the orbit and the fronto-malar suture. The infraorbital foramen, shaped as a horizontally-lying oval, is seen in the middle part of the inferior orbital margin.

The anterior semiaxial projection facilitates a study of the condition of the paranasal sinuses and their relationship to the orbit (the ethmoid labyrinth, however, is poorly differentiated). The X-ray film gives a clear outline of the frontal sinuses which are somewhat magnified due to their being at a fairly great distance from the film. Their posterior portion occupies a greater or lesser part of the superointernal section of the orbit, depending on their depth.

The maxillary sinuses are clearly seen in the X-ray film. To study the orbits and paranasal sinuses, the pictures are taken in two projections (anterior sagittal and anterior semiaxial), since they supplement each other and help to ascertain the condition of both structural formations.

The lateral projection. The patient is so placed as to bring the sagittal plane of the skull as nearly as possible, in a position parallel with the plane of the cassette. The picture gives an idea of the depth of the orbit.

Pictures in the lateral projection may prove useful in estimating the anteroposterior dimensions of the frontal sinus, as well as the condition of its posterior wall.

The condition of the bony walls of the orbit cannot be judged by pictures taken in the lateral projection.

The axial projection. Axial pictures of the skull are necessary for studying the sphenoid sinuses and posterior ethmoid cells.

The examination is particularly effective when the patient is lying on his back, his head tilted so far backward that the crown touches the cassette. The central beam passes to the sinciput through the chin and the base of the skull. This method is contraindicated for fresh injuries to the skull.

Since the sphenoid sinuses lie at a fairly long distance from the X-ray film their image appears enlarged and slightly blurred in outline. This shortcoming can be eliminated by increasing the focal distance; this, however, should be coupled with a longer

exposure, which is undesirable if the patient's head is in an uncomfortable position. In axial pictures the sphenoid sinuses appear somewhat magnified in the film centre. Their contours and the septum between them are fairly definite. Above the sphenoid sinuses are seen the posterior ethmoid cells, as well as the marked outline of the middle cranial fossa, the great wing of the sphenoid bone with the foramen ovale and the foramen spinosum, and the pyramids of the temporal bones.

Examination of the above-mentioned projections will give an insight into the condition of the paranasal sinuses and the orbit, as well as into their relationships. In some cases, examination should be undertaken in a special projection to clarify the topographical relationships between the sphenoid sinuses, the posterior ethmoid cells and the facial nerve canal.

The oblique projection of the skull. In order to examine the optic nerve canal, most authors recommend Rhese's method, which ensures a good image of the posterior ethmoid cells and sphenoid sinus. Since the optic foramen has an irregular shape in this projection, we prefer to conduct the examination in the manner described below. The patient's head is so placed as to have the nose and the external margin of the orbit under study touch upon the cassette; the superior orbital margin is at the same time somewhat elevated (under Rhese's method the orbital margin adjoins the cassette). The central beam passes through the superoposterior quadrant of the sincipital bone and the external margin of the orbit under study and forms 40° and 50° angles with the normal horizontal and sagittal planes of the skull respectively.

The conclusion about the presence of changes in the region of the optic nerve canal should be based on a picture of the canal and the opposite side. Various instruments have been suggested for producing symmetrical images, yet it is not always possible to obtain a symmetrical image of both canals. It is advisable to conduct the investigation with the aid of a craniograph in which two cassettes may be set at different angles.

The above-described methods can be used to produce a distinct image of the optic foramen, which in most cases has a round shape and measures 3 to 5 mm in size; it is located in the inferoexternal quadrant of the orbit, and outwardly to it is seen the supraorbital fissure within which the anterior clinoid process can sometimes be observed. Inwardly to the image of the optic foramen lies the image of the sphenoid sinus closest to the film; farther inwards and downwards lie the posterior ethmoid cells of the corresponding side. The frontal sinus is seen at the superointernal margin of the orbit, and the antrum of Highmore—beneath it (Fig. 10).

In this way, the oblique projection can give an idea of the topographo-anatomical relationship of the optic nerve canal with nearly all of the paranasal sinuses.

The supraorbital fissure. A fairly good picture of this fissure can be obtained in the anterior sagittal projection of the skull, though the inner third of the fissure will be poorly delineated. The best pictures are obtained by photographing each orbit separately on one and the same film, whereupon one half of the cassette is covered with a lead plate, the patient's head is fixed in place in the same manner as for the anterior sagittal picture, and the tube is adjusted appropriately. The tube is then displaced to the side of the closed half of the cassette, 11.5 cm from the median line, and so turned that the central beam aimed at the orbit under study forms a 15° angle to the vertical.

After the first picture is taken the exposed half is covered with the lead plate, the tube is shifted 23 cm in the opposite direction, and the second orbit is photographed at a 15° angle (Fig. 11).

Examination of the supraorbital fissure is of great practical value, since it helps to obtain valuable data in cases where the pathological process is confined to the orbital apex, as well as in the so-called supraorbital fissure syndrome, pulsating exophthalmos and tumours.

The infraorbital fissure. Pictures can be taken in the anterior sagittal projection of the skull where the forehead is brought into contact with the film. The central beam passes through the sagittal plane of the skull at a 20-25° angle open downwards. The infraorbital fissure is projected on to the X-ray film in the infero-external portion of the orbit.

X-RAY SYMPTOMS OF ORBITAL DISEASES CAUSED BY EXTENSION OF INFECTION FROM THE PARANASAL SINUSES

It should be noted that diseases of the paranasal sinuses are often indicated primarily by ophthalmic symptoms, which is the reason why the patient first applies to an ophthalmologist. Should one fail in this case to examine the paranasal sinuses for a primary disease, much time will be wasted on various therapeutical measures without success. Therefore, in case of any inflammatory or tumorous process in the orbit, an X-ray examination of both the orbital region and the paranasal sinuses is necessary.

In this connection we shall mainly dwell on the X-ray symptoms of diseases of the paranasal sinuses. Changes in the orbital region which are identified with X-rays are described in the clinical analysis of the corresponding diseases.

The paranasal sinuses are normally air-filled and readily pervious to X-rays; therefore any process leading to air expulsion produces a shadowing of the sinuses on the X-ray film. In most cases, however, X-ray examination only permits the detection of a pathological process in the sinus.

The shadow may be caused by an edematous or infiltrated mucosa, polyps, cysts, exudations in empyemas, infectious granulomas or tumours filling the sinus. X-ray examination also enables a conclusion to be made regarding the condition of the bony walls of the paranasal sinuses. Changes in the bone are caused by extension of the process both in cases of newgrowths and purulent sinusitis; therefore, when studying the X-ray film special attention should be paid to the borders of the shadowed sinus. The presence of marked outlines will indicate that the bone is not yet involved in the process, whereas blurred sinus contours will warrant suspicion of a bone affection, such as ostitis or osteomyelitis.

Bone changes may also occur as a result of sustained inflammatory processes in the orbit, as well as in prolonged pathological processes. This is revealed in the X-ray film by the presence of intumescences and indurations in bony tissue, loss of air by the sinus, which is indicated by its shadowing.

Polypous proliferations of the mucosa filling the sinus produce a diffuse homogeneous shadowing of the affected area in the X-ray film. The presence in the sinus of circumscribed shadows of a round or pyriform shape with smooth margins may indicate a polyp or cyst (Fig. 12). In such cases, differential diagnosis is rather difficult: the cyst is commonly of a more round form, while the presence of polypous formations in the nose would rather indicate a polyp in one of the paranasal sinuses.

Problems of differential diagnosis between inflammatory diseases and newgrowths will be discussed in the corresponding chapters. We shall only point out here that a more or less marked shadowing of a paranasal sinus depends on the morphological structure of the tumour.

We have reviewed the X-ray symptoms common to various processes in the paranasal sinuses. We shall now discuss the X-ray symptoms of pathological processes, primarily inflammations in certain sinuses.

X-RAY DIAGNOSIS OF DISEASES OF THE FRONTAL SINUS

The greatly varying structure of the frontal sinuses complicates the X-ray diagnosis of their various diseases. The sinuses being unequal in size and depth, a shadow may be erroneously suspected to be in the one with less air. The absence of one of the sinuses may be mistaken for a pathological condition.

Should the existence of a frontal sinus be in doubt, the skull must be photographed in the lateral and oblique projections. This often helps to locate the sinus, even if it has not been found in a picture taken in the sagittal projection.

Acute catarrhal inflammations in the frontal sinus are evidenced by a slight decrease in its transparency and by dimness of its

outline. In a chronic process, with the sinus orifice open, there may be no decrease in sinus transparency.

In a bilateral frontal sinus disease the diagnosis is particularly difficult.

In examining X-ray pictures special attention should be paid to the anterior ethmoid cells, which in most cases are likely to be involved in the morbid process, particularly if their outlets lie near the natural orifice of the frontal sinus. Therefore, a shadowing of the anterior ethmoid cells may point to a disease of the frontal sinus, even if the latter is shadowed only slightly.

In polyposis of the mucous membrane the X-ray film will show an irregular shadow, which, however, is not enough for a definite diagnosis of polyposis. Marked polyposis produces an intense shadow, though not so marked as, for instance, in a purulent frontal sinus disease. In the case of a multi-chamber frontal sinus with individual chambers of variable depth, the X-ray film will show irregular transparency in the sinus.

Prolonged inflammation with a chronic course extends to the periosteum and later to the bony walls of the sinus, which is seen as a more intense shadow of the marginal zone on the X-ray film. Considerable induration of bone in the frontal sinus area is encountered in osteodystrophic processes, Paget's disease, syphilis and idiopathic hyperostosis. Prolonged inflammation in the frontal sinus, however, may lead to a resorptive process. Destruction of bone usually occurs where it is thinnest and where blood vessels pass. In the frontal sinus it is confined to the floor forming part of the superior wall of the orbit. Defects in the bony wall cannot be detected by X-rays, because the bone is too thin, while examination in various projections leads to the discovery of defects only occasionally.

The defect may give rise to a fistula which erupts in front of the septum orbitae. It should be borne in mind that pus escape from the fistula may lead to a transient restoration of sinus transparency, which is likely to prompt an erroneous conclusion that the sinus is normal. To avoid this error one should examine the sinus contours and establish a more accurate diagnosis based on the degree of their dimness and induration of the marginal zone.

So far as the X-ray diagnosis of frontal sinus tumours is concerned, the suspicion of a tumour in this sinus, just as in the other paranasal sinuses, is only valid when the intense shadow does not cover the entire sinus.

X-RAY DIAGNOSIS OF DISEASES OF THE ETHMOID LABYRINTH

The most accurate X-ray picture of the ethmoid cells is obtained by examination in the anterior sagittal projection. This may be

supplemented by examination under Rhese's method or its various modifications. X-ray pictures made by this method reveal the relationships between the posterior ethmoid cells, the sphenoid sinus and the optic foramen, which is very important in treating certain diseases of the optic nerve.

In examining the X-ray film it is essential to consider the condition of the internal orbital wall which serves as the external wall of the ethmoid labyrinth. In certain pathological processes, such as phlegmon of the orbit and mucocele, it readily sinks towards the nose and orbit or becomes partially and sometimes completely destroyed.

An inflammatory process in the ethmoid labyrinth will produce a shadow in this region, which will show in an X-ray picture (Fig. 13). A dark shadow is observed in empyema of the labyrinth and in polypous degeneration of the mucous membrane. Great caution should be displayed, however, in taking shadow quality as the only basis for judgement regarding the nature of the process, and the condition of the bony partitions between the cells should be given due attention. In an acute process these partitions are discernible, whereas in chronic diseases, such as polyposis or mucocele, only a structureless, homogeneous shadow is noted. It will be recalled that in many individuals the labyrinth is underdeveloped in general, as a result of which a more or less marked shadow may appear on the X-ray picture of even a perfectly normal labyrinth. Inflammation in the ethmoid labyrinth causes a swelling of the middle turbinates and expulsion of air from the nasal cavity.

Tumours of soft tissue can hardly be differentiated from an inflammatory process by means of X-rays.

X-RAY DIAGNOSIS OF DISEASES OF THE MAXILLARY SINUS

The condition of this sinus can best be judged from a picture taken in the semiaxial projection. The superior wall of the antrum of Highmore, which forms the floor of the orbit, is very thin, as has already been mentioned in the anatomical review, and therefore offers little resistance to any inflammatory process extending to the orbital contents.

An inflammation in the maxillary sinus will produce an intense shadow in the X-ray picture. When the process is acute the shadow will be soft and the sinus contours clearly defined, whereas at the initial stage there will be partial swelling of the mucous membrane, marginal or perimural. The sinus size will decrease only with extension and development of the inflammatory process, a small central section of the sinus remaining the only transparent portion of the X-ray picture (Fig. 14).

The "accompanying shadow" symptom is observed not only at the onset of the disease but also in the convalescence period fol-

lowing the abatement of inflammatory symptoms. It is therefore difficult to decide on the basis of a single X-ray examination whether one deals with the primary stage of a disease or its residual symptoms. It is only a comparison of the data of serial investigations with clinical data that will help correctly evaluate the picture. In examining the X-ray film one should remember that sinus transparency is usually restored after the inflammation has ceased.

In a chronic process, the sinus contours are blurred and the shadow is denser. In empyema the shadow is dark and diffuse, while in disseminated polyposis it has no homogeneous quality even if the entire cavity is filled with polyps. If empyema is suspected the examination should be preferably made with the patient in the sitting posture. Detection of one or a few round shadows may indicate either a polyp or a cyst. The former is more likely when polyps are simultaneously present in the nasal cavity. A cyst may grow in size until it fills most of the maxillary sinus, and sometimes the whole of it.

Involvement of a bony wall in the process and its subsequent destruction may produce a fistula; the bone defect and direction of the fistular channel can be determined on an X-ray picture only after a probe has been inserted into the fistula.

X-RAY DIAGNOSIS OF DISEASES OF THE SPHENOID SINUS

Pictures in the axial projection are taken to estimate the condition of the sphenoid sinuses.

An inflammation in the sphenoid sinus will present a uniform shadow on an X-ray film, whereas polypous degeneration of the mucous membrane and polyps will produce a shadow of irregular density.

Fig. 15 represents an X-ray picture of inflammation in all the paranasal sinuses of the left side, known as left-side hemipansinusitis.

III

Diseases of the Orbit Caused by Inflammations in Paranasal Sinuses

According to the statistics compiled by Berlin and Kohn, diseases of the orbit account for 0.15 to 0.2 per cent of the total incidence of eye diseases, and are inflammations in one out of every three cases.

According to the statistical reports of the Helmholtz Institute of Ophthalmology for the period from 1900 through 1935, inflammatory processes in the orbit have been observed in a much larger proportion of cases than mentioned above, namely, in 0.5 to 0.6 per cent of the total incidence of eye diseases (the reports cover 49,850 in-patients).

Russian scientists have made a great contribution to the study of the above diseases, which are usually complications of empyemas in the paranasal sinuses.

Towards the close of the past century a radical change of opinion occurred, in regard to the pathogenesis of these diseases when it was observed that diseases of the nose and paranasal sinuses were an important source of diseases in the orbit.

An outstanding contribution to the elaboration and dissemination of new concepts of the causes of inflammations in the orbit was made by F. F. Ghermann, a St. Petersburg ophthalmologist. In his reports to the sessions of the St. Petersburg Medical Society on November 29 and December 13, 1894, as well as in his works based on a wealth of clinical and pathoanatomical material, F. F. Ghermann challenged the prevailing view that periostitis and necrosis of the orbital walls were caused by phlegmon in the orbital cellular tissue with a categorical statement to the effect that *phlegmon of the orbit itself was brought about by perforation of the orbital wall in empyemas of the paranasal sinuses.*

In his monography *Symptomatology, Therapy and Prognostication in Orbital Diseases of the Eye Caused by Empyemas in the Paranasal Sinuses* published as a supplement to the *Bulletin of Ophthalmology* in 1898, F. F. Ghermann writes: "In the work of Berlin, who has given the most detailed treatment to the chapter

on diseases of the orbit in Graefe-Saemisch's manual, I have found practically nothing worth citing in support of my view; I must refute certain other concepts which he upholds."

Contrary to Berlin, F. F. Ghermann maintained that "the orbital phlegmon, complicated by perforation of the orbital wall, is probably always exogenous, i.e., originates in one of the paranasal sinuses".

In his critical analysis of the views of Hajek and Grünwald set forth in their special works on suppurations in the nose and paranasal sinuses, F. F. Ghermann had this to say: "The process takes its origin from the nose, and only by way of suppurative inflammation in one or a few paranasal sinuses does it lead to perforation of the bony wall of the orbit with subsequent development of an orbital phlegmon. The latter, therefore, is a secondary rather than a primary disease. This notion is of immense importance for our drophylactic and therapeutic procedures."

ROUTES OF EXTENSION OF INFECTION AND GENERAL PATHOLOGY OF INFLAMMATORY DISEASES OF THE ORBIT

The extension of the inflammatory process from the paranasal sinuses to the orbit commonly occurs by contact. This process is usually encountered in empyemas of the paranasal sinuses, particularly where communication between the sinus and the nasal cavity is partially or completely obstructed by polyps or granulations accumulated at their common orifice, and where evacuation of pathological exudation is therefore difficult. The pressure brought to bear on the sinus walls by pus accumulation brings about a series of consecutive changes in the walls. The first to suffer is the sinus mucosa: round-cell infiltration of the submucous layer appears, followed by superficial and limited ulcerations which later spread over the surface and into the tissue and ultimately affect the entire depth of the mucosa down to the connective tissue stroma.

If the process is not reversed at this stage, the pathological changes soon reach the superficial and then the deep layers of bony tissue. This may portend a diffuse inflammation, unaccompanied by necrosis, or progressive carious ostitis. The latter is characterised by the presence of osteoclasts and formation of typical lacunae.

When the process is confined to the orbital wall of a paranasal sinus, it extends to the orbital periosteum; a lesion in the inferior wall of the frontal sinus causes periostitis of the superior orbital wall, whereas a lesion in the external wall of the ethmoid labyrinth leads to periostitis of the internal wall. Periostitis of the inferior wall of the orbit in consequence of affection of the superior wall of the maxillary sinus is a comparatively rare occurrence.

The soft tissues of the external orbital ring, i.e., the eyelids and conjunctiva, as well as the orbital cellular tissue, often develop

collateral edema as a consequence of purulent sinusitis and lesion of the periorbit. This is a non-inflammatory edema which is the only clinically determinable reaction of the orbital tissues to an inflammatory process in the paranasal sinuses.

Inflammatory changes in the soft tissues of the orbit, particularly purulent changes, including phlegmons, commonly occur in far-advanced necrotic changes in the bony walls of the paranasal sinuses.

Thus, empyema of a paranasal sinus as an etiological factor may cause orbital diseases of various forms and degrees, ranging from non-suppurative periostitis of the orbit with the general symptoms, being mild or quite unmarked, to such a grave disease as phlegmon of the orbit with marked constitutional reactions.

Apart from the above-described route of infection extending by contact from a paranasal sinus to the orbit, diseases of the orbit may be caused by the extension of infection through small venous vessels (vv. perforantes), which perforate the bony wall separating the sinus from the orbit, with formation of thrombo- and periphlebitis, and, though rarely, through the venous branches emptying into the superior ophthalmic vein.

As has been shown by a number of authors these two forms of extension of the infection from the paranasal sinuses to the orbit occur simultaneously; the only question is that of the prevalence of one form over the other. This is precisely what determines the appearance of a particular clinical form of orbital disease.

According to P. Y. Tikhomirov, sinusitis leads to an orbital complication in 3 to 4 per cent of the cases. Most commonly they occur in the case of acute or subacute suppurative diseases of the paranasal sinuses. In latent sinusitis, however, changes in the orbital cellular tissue are also rather frequent. In such cases, it should be borne in mind that it is not always possible to draw a clear-cut distinction between suppurative and simple catarrhal inflammations on the basis of clinical data alone and that by the time the patient with a far-advanced orbital complication is examined empyema of a paranasal sinus may be in the phase of reversal.

PERIOSTITIS OF THE ORBIT

Inflammation of the periosteum is a frequent phenomenon in the pathology of the bony system, and orbital periostitis of rhinogenic origin is by no means an exception in this respect.

The appearance of periostitis is usually ascribed to the presence of an inflammatory focus in bone, which gives rise to an inflammation in the surrounding periosteum.

Periostitis of the orbit arises by extension of the infection from the pathologically changed bony wall of the paranasal sinus to the internal and then the external layer of the periosteum.

Apart from the extension of infection by contact, as has been mentioned above, the latter may be introduced into the orbital periosteum from a paranasal sinus through the blood vessels.

In the majority of cases, periostitis of the orbit is caused either by purulent or catarrhal inflammations of the paranasal sinuses. The latter are commonly encountered in children.

In empyemas of the paranasal sinuses, the orbital periosteum is involved in the pathological process secondarily, i.e., following the extension of inflammation in the bone of the orbital wall to the periosteum. This gives us reason to consider it in combination with, rather than in isolation from, the causative process in the bone, i.e., to suppose osteoperiostitis.

The basic forms of rhinogenous periostitis of the orbit are as follows: (1) simple, or non-purulent, periostitis (periostitis simplex) and (2) purulent periostitis (periostitis purulenta).

1. **Simple periostitis of the orbit** of rhinogenous origin is most commonly encountered in acute empyemas of the paranasal sinuses following influenza, scarlet fever and other infectious diseases, and is a reversible condition. Its morphological substrate is hyperemia and serocellular infiltration of the periosteum. Macroscopically this is expressed in a slight thickening of the periosteum.

In periostitis with a prolonged and favourable course the development of fibrous tissue, primarily in the external layer of the periosteum, leads to the formation of a connective tissue callosity, as a result of which the periosteum accretes with the bone around the defect in the bony tissue to form a fibrous callosity which prevents the infection from extending to the soft tissues of the orbit.

Simple periostitis mostly occurs as a local process confined to a limited portion of the orbit where palpation reveals a slight swelling and tenderness. Appropriate conservative treatment eliminates the inflammatory symptoms. The simple form of periostitis which ends in complete recovery sometimes leaves fibrous deposits, where palpation reveals a certain thickening of the bone, or rather the periosteum.

2. **Purulent periostitis of the orbit** of rhinogenous origin develops either from the simple form as a result of purulent infection, or by extension of suppuration from the carious bony wall of one of the paranasal sinuses.

Microscopically, purulent periostitis differs from the simple form in that the serocellular infiltration becomes frankly cellular, purulent. These changes develop on the internal surface of the periosteum facing the bone. As the symptoms aggravate, the internal layer of the periosteum becomes saturated with the pus that accumulates between the periosteum and the bone to produce subperiosteal edematous and then purulent infiltration. Since the periorbit is loosely connected with the bone, the accumulated pus

separates them and gives rise to a subperiosteal abscess. This permits us to regard the latter as a further stage in the progress of purulent periostitis—a new condition resulting from pus exudation, separation of the periosteum and pus accumulation under the periosteum.

Subperiosteal abscesses will be discussed below.

THE CLINICAL PICTURE OF PERIOSTITIS PROVOKED BY LESIONS IN INDIVIDUAL PARANASAL SINUSES

Purulent periostitis runs an acute course from the very onset, and is accompanied by constitutional reactions, such as fever, headache and debility. There may be considerable edema of the peripheral soft tissues, lesions of the periosteum, pain, and tenderness on palpation. The local symptoms of orbital periostitis are extremely diverse, which is due to the variable location of the periosteal focus of affection in the anterior or posterior portion of the orbit; the latter depends on the characteristics of the topographo-anatomical position of the paranasal sinus which has caused the lesion of the periosteum.

Therefore, if orbital periostitis has been provoked by a lesion of the anterior group of cells of the paranasal sinuses, which include the frontal and maxillary sinuses, as well as the anterior cells of the ethmoid labyrinth, the symptomatology is limited to edema of the eyelids and a slight swelling of the periosteum. In affections caused by empyemas of the sphenoid sinus and the posterior cells of the ethmoid labyrinth, vision disorders come to the fore, along with marked signs of edema in the retrobulbar cellular tissue.

This diversity in the clinical symptoms of rhinogenous periostitis necessitates a detailed consideration of its symptomatology with regard to each particular paranasal sinus.

Orbital periostitis is commonly encountered in empyema of the frontal sinus and ethmoid labyrinth, and less frequently in the case of lesions of the antrum of Highmore.

1. **The frontal sinus and ethmoid labyrinth.** The early stages of simple periostitis are marked by a slightly edematous and pale swelling of the skin of the forehead and upper eyelid at the superointerior angle of the orbit, which is intermittent and painful on pressure, as well as by an injection of the eyeball conjunctiva, chemosis and other disturbances caused by the inflammatory reaction. The edema caused by the obstruction of secretion persists until the disappearance of congestive symptoms. The early period is characterised by paralysis of such muscles as the m. levatoris palpebrae superioris, m. recti superioris, m. recti medialis, and by an associated diplopia, commonly transient.

Thus, edema and myoparalysis are the only early symptoms of the disease. A swelling on the periosteum develops at a later

time, when the protective connective tissue torus has formed. This swelling is easily felt by palpation only when it is located in the anterior portion, particularly at the orbital margin.

Marked purulent periostitis in the posterior portion of the orbital roof is encountered in case of a deep frontal sinus or a considerable backward extension of the ethmoid labyrinth. It is often attended with collateral edema of the retrobulbar cellular tissue, which grows fairly large and persists for a long time.

2. **The maxillary sinus.** Empyema in this sinus seldom leads to periostitis of the orbit. The clinical symptoms vary in relation to the degree and extension of the inflammation. Thus, if the latter invades the orbital margin or the anterior portion of the inferior orbital wall, there is always redness and swelling in the lower eyelid, edema or chemosis in the inferior parts of the ocular conjunctiva and even swelling in the neck.

In periostitis of the middle and posterior portions, one can observe in addition a forward and upward displacement of the eyeball and a series of other disturbances, including even amaurosis.

In periostitis attended with collateral edema of the retrobulbar cellular tissue there is a marked obstruction of eyeball mobility, as well as symptoms of inflammation of the optic nerve.

3. **The sphenoid sinus.** Periostitis associated with empyema of the sphenoid sinus is an exceedingly rare occurrence. In this condition, the principal symptoms are those characteristic of an optic nerve lesion, which is due to the sphenoid sinus lying in close proximity to the optic nerve canal, particularly in the topographical variants often encountered here (see Chapter I).

SUBPERIOSTEAL ABSCESSES OF THE ORBIT

Abscesses located between the periorbit and the bony wall of the sinus form as a result of pus infiltration and accumulation on the site of affection and represent in a way a further stage in the progress of purulent periostitis.

The mode of formation of a subperiosteal abscess is not always the same. In some cases, pus accumulation under the periosteum occurs as a result of osteomyelitis in the bone and pus infiltration from the paranasal sinus directly under the periosteum (Golovin's infiltration abscess). The pathological essence of the process is as follows: round-cell infiltration first develops in a limited portion of the sinusal mucosa; then a mucosal defect forms in the place of ulcerative infiltration; and finally the appropriate part of the bone devoid of mucosa (mucoendosteal layer) begins to necrotise, as a result of which the bone is perforated and pus from the paranasal sinus reaches the orbital periosteum.

Such cases are practically identical with those where pus penetrates through a thin fistula in the mucosa of the sinus and bone;

in so far as the connection between them is very loose this later leads to separation of the periosteum from the bone.

A subperiosteal abscess sometimes follows a simple inflammation of the periosteum; an aggravation of the existing non-suppurative periostitis is accompanied by hyperemia, serous or serofibrous exudation followed by a purulent infiltration of the periosteum which, increasing, causes edematous infiltration of soft tissues along the periphery of the principal focus. Purulent impregnation of the internal layer of the periosteum will lead to separation of the periosteum and development of a subperiosteal abscess.

The latter may also develop in the absence of macroscopically determinable defects in the bony wall of the sinus, apparently resulting from venous thrombosis and disintegration of the infected thrombus.

A subperiosteal abscess is often attended with collateral edema of the retrobulbar cellular tissue, which may produce exophthalmos and disturbance of eyeball mobility. The period of abscess formation in acute cases sometimes does not exceed two or three days.

Pus from the subperiosteal abscess pushes its way forwards (rather than backwards—to the retrobulbar space), forming a fistulous passage ending on the skin of the eyelid, at its middle third or at the orbital margin.

Examination of the pus will reveal the same flora as in the purulent contents of the paranasal sinus, i.e., staphylococci, Fränkel's diplococci, etc.

The clinical symptoms of an orbital abscess in lesions of different sinuses are variable.

Subperiosteal abscesses in empyemas of the frontal sinuses. The symptomatology of these abscesses depends on a number of factors, such as the gravity of the process in the sinus, the latter's size, the point of perforation in the bone of the superior orbital wall and the periosteum, and the size of the abscess. In empyemas leading to a subperiosteal abscess the picture may be the same as in periostitis, the only difference being the presence of more obvious pathological symptoms. There is a markedly fluctuating bulging at the inner angle of the orbit, sometimes in the middle of the upper orbital margin, and even at the outer angle of the orbit in the case of a disease in a sinus extending far outwards. The skin in this portion is red and sometimes so tense as to be glossy. Fistulas in the orbital wall of the frontal sinus arise where the venous roots penetrate into the orbit through the bone. The points where the bony wall is perforated are as follows: the supero-internal angle of the orbit, the portion situated below and behind the fovea trochlearis and the platform lying somewhat behind the incisura supraorbitalis. A subperiosteal abscess may also burst into the eyelids; after the fistula has formed and the empyema

has discharged its contents, edema of the eyelids and swelling will diminish and sometimes disappear altogether.

For a correct interpretation of the clinical picture one should know the posterior and anterior limits of the frontal sinus; in the presence of a deep sinus determinable by X-rays it should be remembered that its inferior wall may be broken in the posterior section, leading to the formation of a retrobulbar abscess with all its clinical symptoms, such as exophthalmos, displacement of the eyeball to the side opposite to the inflammatory focus, limited eyeball mobility, diplopia, etc. A downward and outward displacement of the eyeball may result in crossed diplopia.

In a slow chronic process the skin may be ruptured in the middle part of the eyelid, inflammatory symptoms in the latter and in the eye (in particular changes in the refractive media and the ocular fundus) being either absent or insignificant and the acuity of vision remaining normal.

Subperiosteal abscesses with a severe onset are attended with fever, chill and headache, and run a particularly severe course when complicated by an abscess in the orbital cellular tissue.

Subperiosteal abscesses in empyema of the anterior ethmoid cells develop slowly, usually at the entrance to the orbit, above the internal ligament or in the region of the supero-internal margin of the orbit. There is tenderness on pressure applied to the swelling, and a fistula often forms at the inner palpebral angle or in the region of the lacrimal sac. In such cases there is a danger of dacryocystitis being caused by a pathological condition in the anterior cells of the ethmoid labyrinth.

Apart from the swelling, a characteristic sign of a subperiosteal abscess caused by suppuration of the anterior ethmoid cells is hyperemia in the inner half of the ocular conjunctiva.

A lesion of the posterior cells of the ethmoid labyrinth and the sphenoid sinus is characterised by central scotoma, increase of the blind spot and paralysis of the abducens and oculomotor nerves, which develop due to the inflammatory process extending to the optic nerve in the region of its entrance into the orbit.

Subperiosteal abscesses in empyema of the antrum of Highmore are rarely encountered in adults; in children they are more frequent, which is due not so much to the pathological process in the maxillary sinus as to lesions of the teeth and osteomyelitic changes in the superior maxillary bone.

The clinical symptoms of an abscess caused by empyema in the antrum of Highmore depend on abscess location. In a subperiosteal abscess formed near the orbital margin there is redness, edema and swelling of the lower eyelid and sometimes the cheek, as well as chemosis of the lower portion of the ocular conjunctiva.

An entirely different picture is seen in the case of an abscess forming in the posterior portion or of a lesion of the entire inferior

wall of the orbit, where the above-mentioned symptoms are joined by displacement of the eyeball forwards and upwards with limitation of its mobility downwards. In such cases, there is reason to suspect that the retrobulbar tissue is involved in the process, possibly as a result of affection of the sphenoid sinus and the posterior ethmoid cells in addition to the antrum of Highmore.

This type of subperiosteal abscesses is characterised by disorders of vision, which are more common here than in abscesses caused by empyemas in the other paranasal sinuses.

INFLAMMATION OF THE SOFT ORBITAL TISSUES

Inflammatory processes in the soft orbital tissues may be simple or purulent.

1. **Non-suppurative, or simple, inflammations of the soft tissues** of the orbit and eyelids are exceedingly rare in adults. In children, however, particularly in the newborn and infants, non-suppurative processes in the form of serous infiltration of the soft orbital tissues are very frequent. In view of this and of the fact that of all the paranasal sinuses only the ethmoid labyrinth has fully developed by this period, some authors regard the non-suppurative forms of inflammation of the soft orbital tissues as an indirect sign of ethmoiditis.

In children serous infiltration of the orbital cellular tissue may occur even with a catarrhal inflammation of the ethmoid labyrinth, whereas in adults it is encountered only in the presence of rarefying osteitis of the orbital wall or of a purulent focus in a sinus.

Inflammatory edema of the orbit usually owes its origin to earlier infectious diseases, such as scarlet fever or influenza, which are liable to produce ethmoiditis.

In children with ethmoiditis the inflammatory signs in the orbit are often so marked as to lead to an erroneous presumption of an abscess, which subsequent surgery fails to confirm.

The peculiar clinical picture of non-suppurative inflammatory edema of the orbit has prompted some foreign authors to segregate such forms in separate nosological groups. Rollet, for instance, mentions false phlegmons of the orbit, etc.

Non-suppurative inflammations of the soft orbital tissues include chiefly edema of the eyelids which is the most common form of simple inflammation, and edema of the retrobulbar cellular tissue.

(a) *Edema of the eyelids* is most commonly caused by a lesion of the frontal sinus or an affection of the anterior cells of the ethmoid labyrinth. The nature of these affections is variable: in some cases it may be a non-suppurative catarrhal inflammation determinable by X-rays, in other cases it may be a suppurative process established rhinoscopically, such as enlargement and edema of the middle turbinate, pus in the middle nasal meatus, etc.

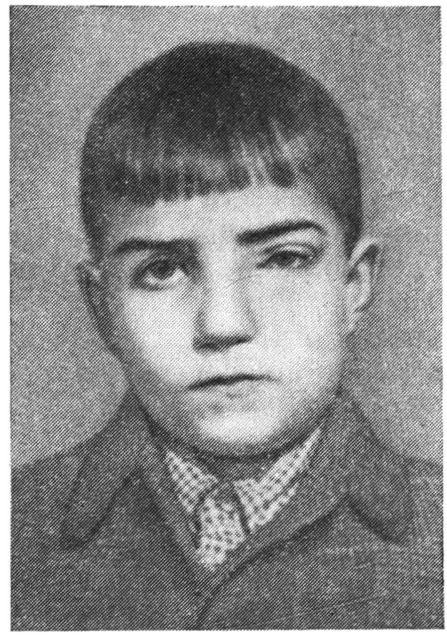


Fig. 16. Edema of the upper and lower eyelids at left. The palpebral fissure is narrowed

The affection is usually confined to the upper eyelid, less commonly to the lower eyelid, while simultaneous edema of both eyelids is even less frequent. In some cases, it extends to the plica semilunaris and to the bulbar conjunctiva, as well as to the lateral surface of the nose. There is tenderness on pressure applied to the reddened portion of the skin at the inner angle of the eye. The mobility of the eyeball is retained in palpebral edema. In most patients, the general condition is normal, sometimes—even though rarely—a subfebrile temperature is observed; very seldom, however, the fever may rise to 38.5-39°C, as in the case reported below.

Case report 1. Patient T., aged 6, suffered a sudden attack of disease. Temperature 38.5°C. Clinical signs: redness and edema of left eyelids; palpebral fissure narrowed (Fig. 16); edema of bulbar conjunctiva; cornea and refractive media transparent; eye fundus without pathological changes; pus in the middle nasal meatus. Skiagraphy: left-side ethmoiditis (Fig. 18). Conservative treatment with heat and nasal cocaine-adrenaline turundas helped remove nasal obstruction and all pathological symptoms in the left eye.

(b) *Edema of the retrobulbar cellular tissue* is encountered in lesions of the posterior cells of the ethmoid labyrinth, most commonly in purulent ethmoiditis.

The clinical symptoms of edema of the orbital cellular tissue in children may be general and local. The former include a rise in body temperature to 39°C and headache often accompanied by vomiting. The local signs are palpebral edema, direct exophthalmos, diplopia and lesion of the abducens nerve. Just as in pal-

pebral edema the vision is unimpaired, the ocular fundus and refracting media remaining unchanged.

In adults non-suppurative edema of the orbital cellular tissue develops at normal temperature, the other general symptoms, very prominent in children with the same disease, being also absent. Local disorders are confined to exophthalmos of varying degree, impairment of vision and paralysis of the eye muscles. The latter two symptoms are not found in children, as we have already seen. The following is an extraordinary case of non-suppurative inflammation of the orbital cellular tissue in a 20-day-old child who had alternate improvements and drastic aggravations of the ophthalmic symptoms, depending on the condition of the nasal cavity.

Case report 2. Patient K., hospitalised for left-side ethmoiditis and exophthalmos. Onset was at night, with redness and swelling of the left eyelids, and copious discharge from the left nasal cavity. Next day, extension of the swelling to the nasal skin. On examination, edema of the left eyelids spreading to the nasal skin, dilated and meandering subcutaneous vessels of the upper eyelid and cyanosis of its skin. Palpebral fissure nearly absent. No discharge from the lacrimal punctum on pressure. Mild congestion of the palpebral conjunctiva and the eyeball at the palpebral angle fold, and purulent discharge from the conjunctival sac, as well as marked exophthalmos. Cornea lustrous. Anterior chamber of normal depth. Iris pattern retained and pupil round. Right eye normal. A great deal of pus in the left nasal cavity, particularly on pressure applied to the lateral portion of the nasal dorsum at the bridge of the nose. Following the administration of penicillin the fever dropped, nasal discharge decreased, exophthalmos and palpebral edema almost disappeared. A week later, however, the fever rose to 38°C, nasal discharge increased, and shortly afterwards cyanosis of the skin of the upper eyelid recurred, and palpebral edema and exophthalmos aggravated. After energetic penicillin therapy all ophthalmic symptoms disappeared; nasal symptoms were the first to disappear, after which the condition of the eye began to improve.

2. Suppurative inflammations of the soft orbital tissues. Diseases of the paranasal sinuses, particularly empyemas, may in some cases give rise to suppurations in the soft orbital tissues, such as palpebral abscess, retrobulbar abscess and phlegmon of the retrobulbar space.

(a) *Palpebral abscess.* As in simple inflammation (edema) the upper eyelid is more liable to affection than the lower. In the former case the disease is usually caused by empyema of the frontal sinus, in the latter case—by suppurative inflammation of the maxillary sinus, or ethmoiditis.

An abscess in the upper eyelid with formation of a fistula may sometimes be seen with pyocele, i.e., a suppurative cystoid distention of the sinus (see Chapter IV).

Fig. 17. Eversion of the middle third of the right upper eyelid, which is drawn up and cicatricially adherent to the supraorbital margin. A fistula with purulent discharge. The palpebral fissure is permanently open

The pathogenesis of a suprapalpebral abscess with formation of a fistula is as follows. As is known, the tarso-orbital fascia accretes very closely with the orbital margin. In cases where rarefying osteitis and bone necrosis resulting from an inflammation of the frontal sinus and the associated osteomyelitis are confined to the orbital margin the fascia attached to it prevents the pus from penetrating into the soft tissues of the orbit and causing the formation of a retrobulbar abscess. Owing to a defect in the superior wall of the orbit the pus in such cases flows down the anterior surface of the tarso-orbital fascia to the convex part of the cartilage, wherefrom it breaks into the soft tissues of the upper eyelid.

Clinically, an abscessed eyelid is sharply edematous, reddened and immobile. The eyeball is usually covered by the affected eyelid, especially in the case of abscess formation in both eyelids. Elevation of the eyelid with an eyelid retractor reveals an edematous and reddened bulbar conjunctiva. There is fluctuation in far-advanced cases. In a spontaneous bursting of an abscess the pus breaks its way outside to form a fistular channel opening on the eyelid skin. Finally, in chronic cases, evacuation of the basic suppurative focus in the paranasal sinus may be followed by formation of a cicatricial traction of the eyelid, ectropion and some other persistent deformities (healing stage).

Case report 3. Patient K., female, aged 28, hospitalised for a year-old fistula of the right upper eyelid. Physical examination: eversion of the middle third of the eyelid, updrawn and cicatricially adherent to the upper margin of the orbit. In the scar region a fistula with a purulent discharge. Eyelids

permanently open (Fig. 17). Otherwise the eye normal. The nose, throat and ear without marked changes. X-ray examination: complete destruction of the upper orbital margin at right, irregular transparency of the right frontal sinus, blurred contours of its lower wall and a shadow in the right ethmoid labyrinth and the maxillary sinus (Fig. 19). Since the long-persistent fistula of the upper eyelid was associated with a disease of the paranasal sinuses, a radical operation was performed on the right frontal sinus and the ethmoid labyrinth, the commissures being removed from the eyelids following a dermo-periosteal incision. The immediate result of the operation was cessation of the inflammatory process and closure of the fistula.

(b) *The retrobulbar abscess* is a circumscribed purulent focus in the orbital cellular tissue. Rhinogenous abscesses develop as a result of a subperiosteal abscess bursting through the periosteum, the pus working its way backwards, towards the retrobulbar space, where it affects the soft tissues.

A retrobulbar abscess may also arise by transmission of infection through the vascular system and in consequence of palpebral thrombophlebitis. A characteristic sign of such transmission is the presence of multiple abscesses.

Irrespective of whether the retrobulbar abscess arises from contact or by metastasis, it is attended with a marked constitutional reaction, such as hectic fever, chills, intensified leukocytosis and ESR (erythrocyte sedimentation reaction), and other signs of a septic disease. The local symptoms are exophthalmos, limited mobility of the eyeball and other disorders associated with congestive phenomena in the vaso-lymphatic system of the orbit.

The symptomatology of retrobulbar abscesses thus differs but little in grave cases from the clinical symptoms of a subperiosteal abscess; in the case of marked symptoms the clinical picture of a retrobulbar abscess is similar to that of an orbital phlegmon. This explains the difficulties which arise in some cases of differential diagnosis of abscesses, particularly prior to their pointing; the above circumstance usually confirms the preliminary diagnosis of "orbital abscess" without specification of its exact location in the orbit itself.

Below are two case reports on orbital abscesses. In the presence of general signs, such as serious constitutional symptoms characteristic of septic poisoning and threatening the patient's life, these cases present a drastic difference between the routes of extension of the infection into the orbit. Case report 4 is an example of the process extending through a defect in the bony wall of the orbit by contact, i.e., by continuation. In case report 5 the clinical picture, the course of the disease and the failure to discover bone defects at operation gave reason to suspect an infection spreading from the paranasal sinus into the orbit through vessels in intact bone.

Fig. 18. The same case as in Fig. 16. Shadowing of the left-side ethmoid labyrinth

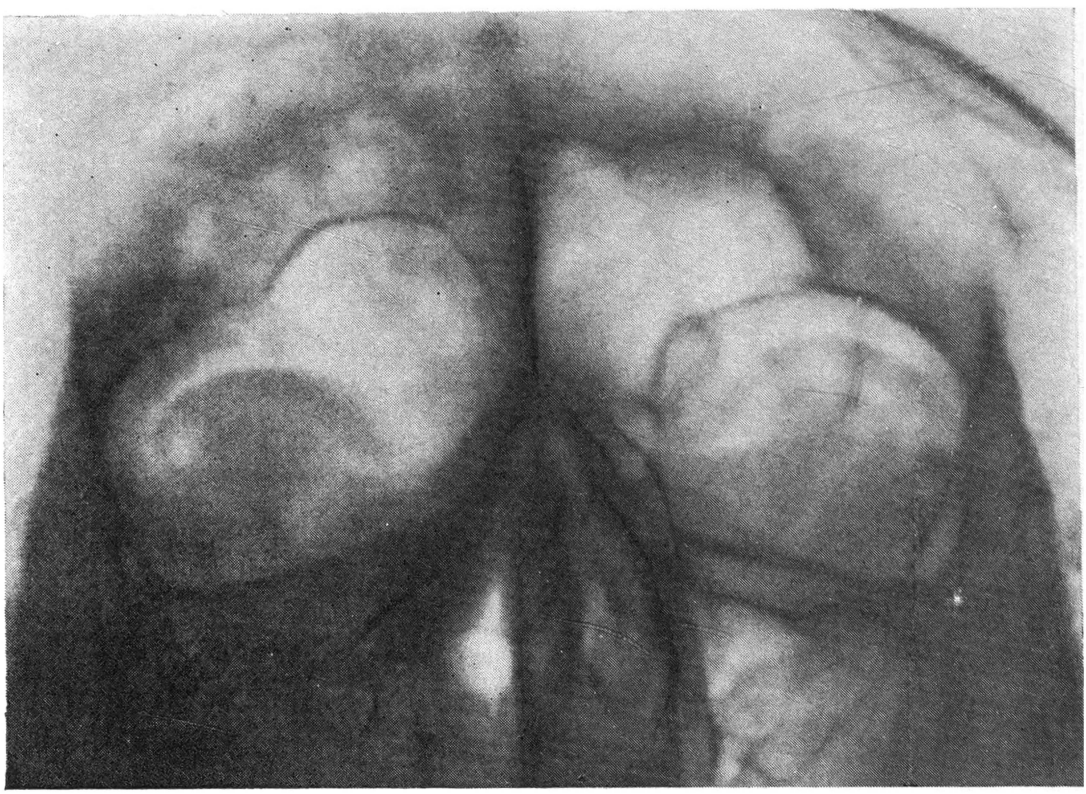


Fig. 19. The same case as in Fig. 17. The X-ray film shows complete destruction of the upper orbital margin at right, irregular transparency of the right-side frontal sinus and shadowing of the right-side ethmoid labyrinth

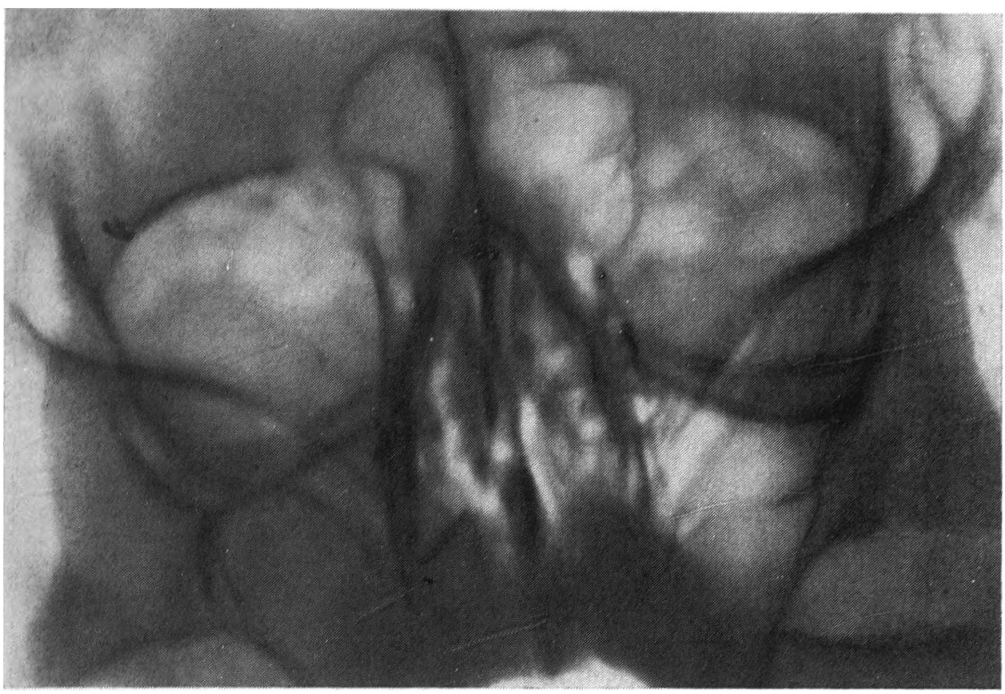


Fig. 21. The same case as in Fig. 20. Shadowing of the right-side maxillary and frontal sinuses

Fig. 22. Shadowing of the frontal and maxillary sinuses on both sidesand the right-side ethmoid labyrinth

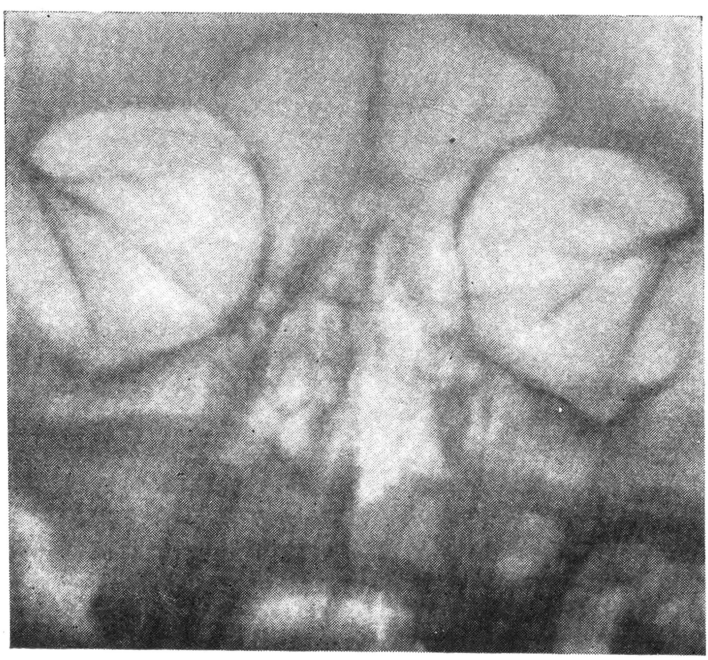


Fig. 23. Shadowing of the frontal and maxillary sinuses and the right-side ethmoid labyrinth

Case report 4. Patient F., aged 56, hospitalised on November 10, 1946, for an abscess in the right orbit. Chronic coryza in anamnesis. Protrusion of the right eye and heavy swelling in the orbital region two days before hospitalisation. General condition grave, with a severe headache, a fever up to 39°C, and a pulse rate of 100. Full consciousness retained.

Right eye: eyelids and surrounding tissues markedly edematous, conjunctiva chemotic, eyeball displaced outwards and a little anteriorly, its mobility being very limited. Cornea transparent, anterior chamber normal, pupil reactive to light, refractive media transparent, ocular fundus normal, vision acuity 0.7. A more detailed ophthalmological examination was impossible in view of the patient's general condition. Left eye normal.

Nose, throat and ear: hypertrophy of the right middle nasal turbinate and a purulent streak in the middle nasal meatus; ears and throat normal. X-ray examination (Fig. 22): irregular shadow in both frontal sinuses and maxillary sinuses, as well as in the right ethmoid labyrinth and orbit; the latter's supero-internal wall indrawn. The neurological status as follows: slight occipital rigidity, moderate bilateral Kernig's sign, insignificant ataxia of left leg.

In view of the abscess in the right orbit being indisputably of rhinogenous origin a radical operation was performed on all the right-side paranasal sinuses on November 11, and the abscess contents were evacuated. The abscess located subperiosteally and in the very depth of the orbital cellular tissue was emptied through an ordinary incision, such as is used for opening the fronto-ethmoid region and tarso-orbital fascia. Both boils communicated through a defect in the periorbit. The changes in the sinuses were as follows: the frontal sinus had a large defect with uneven edges in the internal portion of the inferior wall and a destruction of the cranial wall of the sinus (2 × × 3 cm); the meninx was covered with granulations which were also found in the ethmoid cells; the sphenoid sinus was found to have polyposis and the antrum of Highmore contained, besides granulations, a large quantity of pus and numerous polyps. The operation was followed by a considerable amelioration of the patient's general condition: the swelling of the eyelids, chemosis and other local morbid signs disappeared, the fever abated, and only headaches continued to discomfort the patient. Since an abscess in the right frontal lobe of the brain had been suspected by the neuropathologist even before the operation, a lumbar puncture was performed on December 19. In the puncture sample the protein was 0.33‰, Pandy and Nonne-Apelt reaction ++, cytosis 15/3, monocytes 4, lymphocytes 5, neutrophils 6. These data made it possible to rule out an abscess in favour of only reactive symptoms in the meninges. The further course of the disease was quite satisfactory; simultaneously with the opening of the boils in the paranasal sinuses and the orbit the patient was given penicillin and norsulfazol treatment.

Case report 5. Patient G., female, aged 19, hospitalised on March 25, 1949, for an abscess in the right superciliary region. Five days old swelling of the right upper eyelid after influenza. Eyeball closed and pain appeared in the right superciliary region. Prior to hospitalisation the patient was given streptocide treatment. General condition grave, of a septic type.

Body temperature 39.2°C, pulse rate 92, satisfactorily full. Heavy swelling of the upper eyelid, palpebral fissure opening with difficulty.

No change in the anterior section of the right eyeball. Detailed examination of the eye impossible in view of the patient's grave general condition. Left eye normal. A pulsating purulent streak in the right middle nasal meatus. Pharynx and ears normal.

X-ray examination of paranasal sinuses (Fig. 23): shadow in the frontal and maxillary sinuses, as well as in the ethmoid labyrinth on the right side. Rhinoscopic data supplemented by X-ray examination led to presumption that the morbid process in the orbital cellular tissue, i.e., the abscess, was of rhinogenous origin. In view of this fact, it was decided to perform an operation in addition to conservative antibiotic and sulfonamide treatment, i.e., to open the right frontal sinus and the cells of the ethmoid labyrinth of the same side.

The operation showed that the bony walls of the orbit were intact. In the frontal sinus itself, however, and in the cells of the ethmoid labyrinth a large quantity of pus and numerous polyps were discovered. The periorbit was not opened. No subperiosteal abscess was discovered. Since a high fever persisted following the operation, another operation was undertaken which permitted the detection and opening of an orbital abscess in the cellular tissue. This interference, however, was also a failure, and in a few days' time the temperature soared to 40°C and meningeal symptoms set in, such as occipital rigidity, Kernig's sign, left foot clonus and high tendon reflexes. The lumbar puncture sample was pale and clear, cytosis was 37 in 1 mm, protein 0.4 per cent, lymphocytes 59, monocytes 10, neutrophils 31. Blood inoculation for sterility revealed the presence of non-hemolytic streptococci and staphylococci. The blood picture was marked by moderate leukocytosis (10,400). The ESR (erythrocyte sedimentation reaction) reached 60 mm per hour. Examination of the ocular fundus performed after the second operation revealed dilatation of the fundus vessels in the right eye. Since the fever did not subside even after the second operation and the general condition became much worse, with attendant meningeal symptoms, a third surgical interference was undertaken.

The sphenoid and maxillary sinuses were opened on the right side and both were found to contain pus, polyps and granulations. Following the cleansing of these sinuses, the body temperature gradually (lytically) dropped to normal, the general condition improved, and the ESR decreased to 15 mm per hour.

Epicrisis. The above-described observation is interesting in that the rhinogenous abscess of orbital cellular tissue had developed as an acute condition, apparently through the blood flow. This supposition was corroborated by the operation revealing no evidence of hte spread of infection by contact, the walls of the paranasal sinuses and the orbit being intact, as well as by the entire clinical picture, i.e., the septic condition of the patient and irritation of the meninges.

The fact that recovery followed only after the opening and evacuation of all the foci plainly indicates that in purulent rhinogenous diseases of the orbit it is not enough to open the orbit or a paranasal sinus alone; all the pathological foci must be eliminated.

(c) *Phlegmon of the orbit* (Phlegmone orbitae, thrombophlebitis sive cellulitis orbitae) is a diffuse, progressive, acute uncircumscribed inflammatory process accompanied by infiltration and purulent softening of the loose cellular tissue of the orbit. The extension of the process to the entire cellular tissue is a feature peculiar to phlegmon, which sets it apart from an abscess, where only a circumscribed purulent focus is found.

The causes of orbital phlegmons are variable. These are commonly empyema of the paranasal sinuses, which, according to some authors, is observed in 6 out of every 10 cases.

The relationship between phlegmon of the orbit and empyema of the paranasal sinuses was studied in detail in the late 19th and early 20th centuries. The principal works on this subject belong to F. F. Ghermann, S. V. Ochapovsky and M. S. Gurvich.

"The last decade of the 19th century", writes S. V. Ochapovsky in his monograph (1904), "was marked by a radical change in our concepts of the etiology of phlegmon, attention being focused on diseases of the nose and paranasal sinuses as a major cause of orbital diseases".

In a paper on the *Pathology and Therapy of Thrombosis of the Orbital Veins and Venous Sinuses of the Skull*, Prof. K. K. Orlov notes that the study of suppurative diseases of the orbit and the neighbouring sinuses was promoted by the thesis of M. S. Gurvich of Rostov, which gave an exhaustive description of the venous system of the orbit and all its connections with those of the cavities and sinuses.

These concepts are indisputable today owing to the existence of an efficient X-ray service. Moreover, the records of any ophthalmological institution will confirm the important role which the paranasal sinuses play in the causation of phlegmons of the orbit.

S. I. Talkovsky notes that among the 495,000 patients treated at the Helmholtz Institute of Ophthalmology between 1900 and 1935, phlegmon of the orbit was detected in 93 patients, 38.7 per cent of these having pathological changes in the paranasal sinuses as the precipitating cause. He assumes that the above-mentioned morbidity rate was below the actual rate, considering the inadequacy of X-ray facilities in the pre-Soviet period.

S. I. Talkovsky's assumption is not devoid of reason, and is shared by F. V. Birch-Hirschfeld, who has expressed a similar view. The latter has discovered the presence of empyema in the paranasal sinuses to be the source of infection of the orbit in 409 out of 684 (59.8 per cent) cases of orbital phlegmon. Considering the fact

that the patients were given inadequate rhinological examination Birch-Hirschfeld asserts that the percentage he has established is lower than in reality.

The same view of the incidence of rhinogenous phlegmons of the orbit is held by D. Axenfeld, who maintains that the inflammatory process in the paranasal sinuses, which leads to phlegmon of the orbit, may shortly take a reverse course, whereas the orbital complication continues in an active state and even tends to aggravate. Since it is impossible to state with certainty that no healed lesion exists even in a normal paranasal sinus it is difficult to establish any causal relationship between a lesion of the orbit and a paranasal sinus disease.

Admitting that phlegmons of the orbit occur mostly by extension of the purulent contents of a paranasal sinus to the orbital cellular tissue, S. I. Talkovsky warns against this fact being used for an erroneous conclusion regarding a high rate of ophthalmic complications of sinusitis.

A prominent place among the causes of orbital phlegmons belongs to infectious diseases, particularly erysipelatous inflammation, as well as to furuncles of the nose and palpebral skin, which often lead directly to an orbital phlegmon or first to erysipelas and then to phlegmon. Phlegmons of the orbit may be caused by infectious diseases other than erysipelas, such as scarlet fever and measles, as well as puerperal sepsis and septicemia; such purely metastatic phlegmons of the orbit, however, are exceedingly rare.

Traumas are among the major causes of orbital phlegmons. Cases of phlegmons following operations on the eyelids, lacrimal sac and paranasal sinuses have been reported in literature.

In the female patient S. (case report 8) phlegmon of the orbit was caused by purulent peridacryocystitis; it is easy to visualise this route of infection if one recalls that the venous plexuses around the lacrimal sac broadly communicate with the orbital veins.

Pathogenesis. As an etiological factor empyema of the paranasal sinuses may cause either periostitis or a palpebral abscess, as well as a subperiosteal accumulation of pus, retrobulbar abscess or, finally, phlegmon of the orbit.

The latter condition, which is the most severe of orbital complications, threatening the patient's life, is attended with a series of consecutive changes in various physiological systems of the body, which lead to a drastic change in its reactivity. A major role is played by the degree of permeability of such a mighty barrier as the tarso-orbital fascia, the state of the vascular walls of the orbito-sinual region, certain characteristics of blood supply to this region, and other factors.

Phlegmon of the orbit most commonly occurs by extension of an infected thrombus from one of the veins of the paranasal sinus mucosa into one of the orbital veins, the disintegration of the

thrombus developing in the orbital cellular tissue followed by the formation first of small and then of large abscesses.

The anatomical routes of drainage through the veins and nose to the paranasal sinuses facilitate the spread of infection towards the orbit (vv. palpebrales, vv. frontales, v. supraorbitalis, v. angularis empty into the v. ophthalmica, and the latter communicates with the v. facialis) and the brain. The extension of infection is also aided by the absence of valves in the orbital veins, which tends to send the venous blood either into the facial veins or the cavernous sinus, depending on the position of the head. That is why in inflammations of the paranasal sinuses not only orbital but also intracranial complications may come by way of the v. ophthalmica connected with the cavernous sinus.

The presence of thrombophlebites and periphlebites, as well as of a large number of small abscesses located near the smaller veins proves to a certain extent that phlegmons of the orbit have a metastatic origin. The infection in this case spreads through the veins which penetrate the bony walls of the paranasal sinuses and communicate with the veins of the orbit.

Infection often spreads from a paranasal sinus directly into the orbit by the so-called contact route. In this case phlegmon of the orbit can develop solely after destruction not only of the bony wall (bone necrosis due to a trophic disturbance) but also of the periorbit, a solid fibrous lamina which usually effectively resists the further expansion of the suppuration. The intermediate stage in the development of a phlegmon may be formation of a subperiosteal abscess. Since, however, phlegmon develops acute symptoms within an extremely brief time, from 12 to 24 hours, separate stages of orbital affection, such as periostitis, subperiosteal abscess, etc., can usually be observed clinically.

Infection may also extend through the lymphatic vessels connecting the orbit with the paranasal sinuses; this route, however, has not yet been adequately studied.

Whatever the route of infection, the pathogens (commonly staphylococcus albus and aureus, hemolytic and green streptococci, less commonly Fränkel's diplococcus and Friedländer's pneumobacillus) find the orbit a suitable place for their development and reproduction. We have in mind the wide network of fissural spaces located around the vessels and piercing the retrobulbar cellular tissue in every direction. This network of fissural spaces may be compared to the lymphatic spaces.

According to Birch-Hirschfeld's summary statistical data covering 409 cases of orbital phlegmons, they are most commonly caused by empyema of the frontal sinus (29.8 per cent). The second most frequent cause is suppuration of the maxillary sinus (21.8 per cent) and the third—purulent ethmoiditis (20.5 per cent). The rarest cause of orbital phlegmons is empyema of the sphenoid

sinus, which accounts for only 6.7 per cent of the cases. The rate of orbital phlegmons caused by combined lesions (pansinusitis) stands at 14.7 per cent.

Phlegmons of the orbit develop not only at the acute stage of sinusitis but also in sinual empyemas with a chronic course.

The pathoanatomical changes characteristic of orbital phlegmon have been studied in detail by S. V. Ochapovsky in experiments on dogs. The changes he has discovered are characterised by a marked reaction of the vessels and cellular elements of the orbital connective tissue. The first stage of the phlegmonous process is marked by expansion of the vascular lumina and their invasion by red and white blood corpuscles.

The leukocytes emigrating from the vessels fill the entire loose cellular tissue; large leukocyte accumulations are observed around the vessels and muscles. Some leukocytes penetrate into the muscular tissue, push apart and destroy the muscle fibres.

Changes also occur in other tissues of the orbit, such as the periorbit and nerves, including the optic nerve, notwithstanding its solid sheath. In severe phlegmons of the orbit the ciliary ganglion is also affected. In consequence of disappearance of fatty cells, which are replaced by white blood corpuscles, the cellular tissue loses its fatty character.

As a result of profuse exudation from the vessels, which becomes fibrinous, the orbital cellular tissue becomes markedly infiltrated; hence a considerable increase in the volume and tension of the soft orbital tissues, which lends an especially hard consistency to the infiltration.

Another characteristic of a phlegmon is the formation of thrombi in the blood vessels, primarily in veins (hence the name of phlegmon—thrombophlebitis). Thrombophlebitis and thromboarteritis produce necrosis of parts of the cellular tissue, the softening of foci being followed by the formation of purulent cavities, i.e., the so-called secondary abscesses. Suppuration in the orbital cellular tissue usually develops by the end of the first week, the pus being discharged by various routes, mostly through the soft tissues—the palpebral skin or conjunctiva — following the course of the fascias and nerves.

The picture given above of pathoanatomical changes caused by phlegmons of the orbit has been observed by V. P. Filatov and a number of other clinicians.

Apart from extensive destruction of the cellular tissue by bilateral phlegmons of the orbit, some investigators have observed a simultaneous erosion of the bony orbital walls.

Elimination of a pathological process takes much time. In S. V. Ochapovsky's experiments on animals, regenerative symptoms in the presence of trends towards reversal appeared on the fourth day and reached a climax on the eighth day.

Regenerative phenomena, which today are more frequent owing to the use of sulfonamides and antibiotics, may be observed during the reversal of the disease. They essentially consist in the formation of granulation tissue elements (young connective tissue cells, karyokynetic figures) separating the affected area from normal tissue; in some parts this granulation tissue replaces destroyed muscular tissue. The development of this barrier is concurrent with the formation of thrombi, resorption of inflammatory foci and conversion of the phlegmon into one or more small abscesses with a subsequent course characteristic of this particular form of the disease.

Clinical symptoms. Phlegmons of the orbit, as has been noted above, have an acute course from the very outset, which is particularly typical of cases developing metastatically.

The general symptoms of the disease are above all a grave malaise of the septic type, with a high fever of above 39°C, permanent or hectic, marked by a lack of correspondence between fever and the absence of pulse-rate acceleration (70-80), chills, headaches, and debility, all of which are regarded as an oculocardiac reflex (S. I. Talkovsky). Remissions indicate either the development of purulent foci or (in a grave general condition with severe chills) septic poisoning.

The signs of severe septic poisoning are particularly marked in cases of thrombophlebitis extending beyond the orbit, the blood vessels of the face and neck (primarily the v. jugularis and its branches) and those of the brain being involved in the process.

Diseases of the cavernous sinus run an extremely severe course, as attested by the patient's pale-muddy complexion, chills, high temperature, insomnia, convulsions, trismus, nystagmus and other signs pointing to affection of the cavernous, transverse and longitudinal brain sinuses.

The local signs of orbital disease may be summed up as changes caused by disturbed blood circulation, as a considerable expansion of the vessels of the ocular fundus and as phenomena associated with pressure on the eyeball. The latter include forward protrusion of the eyeball, limitation of its movements in every direction, marked tenderness on pressure, and pain within the orbit, whereas no pain is felt on pressure applied to the bony margins of the orbit.

In phlegmons of the orbit, some authors report having observed paresis and stable paralysis of the muscles (including paralysis of accommodation), anesthesia and ulceration of the cornea, and—at the later stages of the process—atrophy of the optic nerve, concentric, temporal or nasal narrowing of the field of vision, thrombophlebitis of the veins of the retina, hemorrhages from its vessels, and even its exfoliation. The above-described complications, as well as panophthalmitis, are rarely encountered with phlegmons of the orbit. S. V. Ochapovsky succeeded in finding only 13 cases of such complications in the literature (A. A. Shcheglova).

The diversity of clinical symptoms in phlegmons of the orbit is associated primarily with the general reaction of the body and local changes caused by affection of one or another paranasal sinus.

According to data of the Helmholtz Institute of Ophthalmology the most frequent cause of orbital phlegmon is *empyema of the maxillary sinus.*

The development of orbital phlegmon in empyema of the maxillary sinus is facilitated by the presence in the orbit of a broad venous network connected with the veins of the sinus, as well as by the possible extension of thrombosis through the fissura orbitalis inferior.

In nurselings and young children phlegmons of the orbit are nearly always associated with a lesion of the superior maxillary bone, usually of osteomyelitic origin. An important role in the latter's diseases is played not only by the exogenous but also, and to a greater extent, by the endogenous factors. The remnants of myxomatous tissue and vascularisation of a somewhat different nature than in adults, on the one hand, and the weak resistance of the child's body, on the other, create favourable conditions for the process. This leads to inflammations of bony tissue with its rapid softening and sequestration; in the case of inadequate pus drainage owing to the cellular structure of the maxilla such sequestration is encountered more frequently.

It should be borne in mind that phlegmons of the orbit may arise from dental lesions followed by empyema of the maxillary sinus. The mode of entry of this infection is as follows: in acute periostitis of the maxilla the process either extends to the floor of the orbit, or through the open channel in the tooth alveolus enters the maxillary sinus, wherefrom it reaches the orbital floor and cellular tissue through veins and by direct contact. In children this route of infection can be described as follows: since the sinus has not yet formed in the maxillary bone, the canine teeth are so deeply wedged in the bone that their roots touch the orbital floor.

In addition to the intense edema of both eyelids caused by empyema of the maxillary sinus, phlegmon of the orbit is accompanied by limited mobility of the eyeball, a very marked exophthalmos, muscular paralysis, impairment of vision, signs of choked disc and retrobulbar neuritis. In some cases, destruction of the floor and edge of the orbit may give rise to an orbital fistula.

Lesions of the ethmoid labyrinth are also a frequent cause of orbital phlegmons, particularly in children, as sequels and complications of acute infectious diseases such as measles, scarlet fever, etc.

The principal symptom of orbital phlegmon of *ethmoidal origin* is a progressive impairment of vision concomitant with eye protrusion forward and outward, particularly in cases of affection of the posterior ethmoid cells. When the anterior ethmoid cells

are involved phlegmon of the orbit itself is often attended with a phlegmonous affection of the lacrimal sac.

According to data of the Helmholtz Institute of Ophthalmology phlegmons of the orbit arising from inflammations (empyema of *the frontal sinuses*) are relatively rare. The first to develop is usually septic thrombosis of the superior longitudinal sinus followed by phlegmon of the orbit. S. I. Agroskin described a case examined by Müller when not only the clinical picture, such as severe orbital complications resulting from acute left-side frontitis, but also the suppuration and defect in the orbital roof discovered at operation indicated that the infection had spread by contact from the frontal sinus; autopsy, however, revealed thrombophlebitis of the superior longitudinal sinus. The transition of infectious germs from the frontal to the superior longitudinal sinus is facilitated by the venous blood from the sinus and its walls draining through the bony diploetic veins into the external frontal vein which communicates with the superior longitudinal sinus. The latter in turn is connected through the vv. ethmoidales anterior and posterior with the v. ophthalmica superior, whose intracranial portion communicates with the veins of the dura mater and the superior longitudinal sinus; it is probable that in Müller's observation, mentioned above, the process at first spread by contact, causing the formation of a subperiosteal abscess and destruction of the orbital roof, with thrombophlebitis of the orbital veins developing subsequently.

S. I. Agroskin found in literature 30 cases of septic thrombosis resulting from a lesion of the frontal sinus. It may be interesting to mention that between 1936 and 1950 19 patients at the S. P. Botkin Infirmary in Moscow received treatment for septic thrombosis of the superior longitudinal sinus, only one of them having frontitis as an etiological factor.

The symptoms of septic thrombosis of the superior longitudinal sinus are high fever, metastases in different organs, headache in the sincipital region, the meningeal syndrome, and, according to O. S. Nikonova, tonic and clonic convulsions. The local signs are edema of the sinciput, forehead, eyelids and the root of the tongue; a subperiosteal abscess of the forehead skin is also frequently noted.

Empyema of the sphenoid sinus is rarely met with as an isolated disease, and even less frequently does it serve as the cause of orbital phlegmons. In these rare cases, the brain sinuses, above all the cavernous, as well as the transverse and longitudinal sinuses, may become blood-clotted simultaneously in consequence of osteomyelitis of the sphenoid bone.

The first to develop is thrombosis of the cavernous sinus, which is followed by thrombosis of the orbital veins and the growth of a phlegmon. This rhinogenous origin of phlegmons is similar to the otogenous origin of orbital phlegmons, where the suppurative process in the mastoid cells extends to the adjacent sigmoid sinus

and then to the other brain sinuses, including the cavernous sinus, to cause symptoms of thrombophlebitis later extending to the veins of the orbit.

The symptomatology of orbital phlegmons in empyema of the sphenoid sinus depends on the existing anatomical relationships between the sphenoid sinus, optic nerve and cavernous sinus, on the one hand, and the cavernous sinus and ophthalmic veins, and the 3rd, 4th, 5th and 6th pairs of cranial nerves, on the other.

The most marked symptoms are those characteristic of thrombosis of the cavernous sinus, such as bilateral exophthalmos with a forward protrusion of the eyeball, icteric colour of the sclera, palpebral edema, chemosis, and later with loss of vision and paralysis of the eye muscles. The immediate cause of blindness is transition of the suppurative process to the optic nerve, which is compressed in the optic canal. Thrombosis of the cavernous sinus is often fatal as a result of meningitis and even a brain abscess.

The indication of orbital phlegmon being complicated by thrombophlebitis of the cavernous sinus is the extension of the process to the other, healthy eye within a very brief time.

Besides the general symptoms seen in thrombosis of the cavernous sinus, thrombosis of the transverse and longitudinal sinuses is characterised by edema of the skin around the mastoid process (thrombosis of the transverse sinus), as well as on the forehead and temple (thrombosis of the longitudinal sinus).

PSEUDOCHOLESTEATOMATA OF THE ORBIT

Pseudocholesteatomata of the orbit are exceedingly rare. In the majority of cases, as reported by G. P. Teplov, T. V. Birich and O. I. Belyayeva, L. Y. Paskhaver, F. I. Dobromylsky, I. I. Shcherbatov, and others, pseudocholesteatoma of the orbit developed due to extension of an analogous process from a paranasal sinus, primarily the maxillary. The comparatively rare incidence of pseudocholesteatoma of the paranasal sinuses is proved by data of the E. N. T. clinic at the Moscow First Medical Institute, as reported by V. I. Amitin: in the 4,000 operations on the paranasal sinuses performed between 1930 and 1950 pseudocholesteatoma was discovered in only 30 cases. In all of them the lesion was confined to the maxillary sinus, yet in two cases it was combined with affection of the ethmoid labyrinth.

Etiology and pathogenesis. Much is still doubtful and therefore controversial in the etiology of pseudocholesteatoma of the paranasal sinuses. Yet it has been established that it develops primarily where there is an aggravation of chronic purulent inflammation of the paranasal sinuses following recovery from influenza: less frequently the origin of pseudocholesteatoma is associated with

a dental lesion leading to osteomyelitis of the bony walls of the maxillary sinus.

K. L. Khilov holds that pseudocholesteatoma of the maxillary sinus may develop from pararadical cysts. According to S. Y. Kvitko, it is associated with periodontitis and chronic osteomyelitis of the sinusal walls.

B. S. Preobrazhensky, B. N. Lebedevsky, N. N. Lozanov, G. B. Rukavishnikova, I. M. Utrobin and S. L. Shapiro have reported pseudocholesteatomata arising from open or closed fistulous wounds of the maxillary sinus.

The origin of pseudocholesteatoma is presumed to be associated with extension of the facial skin or epithelium of the oral mucosa into the sinus, though this fails to explain all the pathogenetic factors involved.

The osteomyelitic process developing in the bony walls of a traumatised sinus produces drastic changes of nerve nutrition both in the submucous layer and in the epithelium lining the mucous membrane. Metaplasia of the columnar epithelium into a stratified squamous epithelium tending to cornify is the immediate cause of the accumulation of the epidermis, i.e., the growth of chpseudocholesteatoma. That is why it is regarded by some researchers as a product of the stratified columnar epithelium. This fact explains its development in the absence of injuries or fistulas. As has been shown by T. N. Milstein on experimental material, the inflammatory changes of the sinusal mucosa are another factor contributing to the development of pseudocholesteatoma.

Pathological anatomy. The morphological characteristics of pseudocholesteatoma are as follows: an osteomyelitic process in the bony walls of a paranasal sinus, metaplasia of the columnar epithelium into a stratified squamous epithelium with formation of "pearls" in the subepithelial layer, epidermisation of glands, and infiltration of the stroma by lymphoid and plasmatic cells. Cornified masses of the epidermis are seen on the surface of the mucous membrane. The accumulation of plates appearing as flat, nucleus-free epithelial cells of a whitish-yellow colour with a pearly hue, which are concentrically arranged and polygonal, and completely lack a connective-tissue stroma, is the result of continuous desquamation and swelling of the epithelium. The necrotic masses discovered in the sinus consist of a desquamated polymorphous epithelium and coagulated pus with an admixture of cholesterin.

Microbiological examination may disclose a coccic flora in various combinations.

Clinical symptoms. According to the three etiological factors underlying the development of pseudocholesteatoma, patients associate its onset either with empyema of a paranasal sinus, or with the extraction of a tooth, or, finally, with a gunshot wound.

The common permanent symptoms of pseudocholesteatoma of the paranasal sinuses, according to V. I. Amitin, are headache, nasal obstruction, and fetid discharge from the nose; the presence of pus in the middle nasal meatus, a swollen mucosa and displacement of the lateral nasal wall towards the nasal septum; X-ray photography reveals, in addition, a dense, diffuse, unilateral shadow in the antrum of Highmore, which is the most liable to this affection. During its surgical opening considerable changes of bone are discovered such as destruction of its medial wall, which is the most common; moreover defects are occasionally found in the anterior wall of the sinus. The sinus itself may be found to contain fetid cholesteatomatous masses which in the case of considerable destruction of the medial wall of the maxillary sinus may easily penetrate into the nasal cavity.

The characteristic signs of pseudocholesteatoma of odontogenous origin are marked swelling of the cheek extending to the eyelids and the nasal dorsum (less frequently—abscesses of the cheek), and fistulas in the tooth alveoli adjoining the floor of the maxillary sinus.

In pseudocholesteatoma associated with a gunshot wound, fistulas leading into the maxillary sinus are not infrequently discovered on the face.

Treatment. In lesions of the maxillary sinus, the best method of surgical treatment is a modification of Caldwell-Luc's operation. The frontal sinus is opened for removal of pseudocholesteatoma by the Jansen-Ritter method, since the osteomyelitic process usually destroys its floor.

As will be seen from the report presented below, standard incisions for opening the frontal sinus must sometimes be supplemented by arbitrary incisions chosen in relation to the primary site and extension of pseudocholesteatoma.

One of the two case reports given below refers to pseudocholesteatoma of the maxillary sinus and ethmoid labyrinth, the other—to a lesion of the frontal sinus, orbit and frontal bone.

Case report 6. Patient A., aged 38, hospitalised with complaints of swelling at inner angle of left eye, palpebral edema and fever rising at times to 38.4°C; ill for 5 days. Physical examination: swelling of left cheek, closure of left eye, edema and hyperemia of skin around nasal root and dorsum. Rhinoscopy: marked edema of left-side nasal mucosa, obliterated nasal meatuses, middle and inferior turbinates adherent to nasal septum, much pus in left side of nose and nasopharynx, fetid odour from mouth, fluctuating swelling on left-side hard palate, on a level with 5th and 6th teeth; its opening was followed by purulent discharge. Two days later a fistula appeared in the area of the swelling at the inner angle of the left orbit. X-ray picture: left side of frontal sinus cloudy, left-side ethmoid cells blurred, nasal meatuses on the same side wide but structureless, and left maxillary sinus seen as

dense, diffuse shadow. An operation made on the latter and on the ethmoid labyrinth revealed fetid pus and cholesteatomatous masses. The fistula at the inner angle of the eye communicated with the ethmoid labyrinth; a defect was discovered in the medial wall of the sinus.

Case report 7. Patient F., female, aged 55, hospitalised for orbital tumour several years old. Physical examination: on right side of forehead dense, immovable and painless tumour looking as a plait stretching lengthwise upwardly and outwardly from middle third of upper orbital margin; at right palpebral fissure was lower than at left, upward eyeball movements limited. X-ray examination (Fig. 24) revealed a 3.5 cm long and 0.8 cm wide cleft-like defect with smooth and even edges in right frontal bone. The cleft began in the frontal bone at a point lying 3.5 cm from superior orbital margin, whose middle third was involved in the defect, and somewhat broadened downwards to end in a pouch with marked outlines, enclosing the infero-external region of the right frontal sinus. Rhinoscopical examination revealed no pathology. An operation was undertaken. Upon separation of soft tissues from the roof of the orbit white cholesteatomatous masses were discovered, which filled the frontal sinus and the upper portion of the orbit; the floor of the frontal sinus was found to have been destroyed. Following the removal of a large quantity of cholesteatomatous matter with remnants of the matrices an additional incision was made at right angles to the initial one and carried upwards from the internal margin of the brow. After the lips of the wound had been drawn apart and the soft tissues removed a defect filled with cholesteatomatous masses was detected in the frontal bone at a distance of 1.5 cm from the orbital margin. After the masses had been removed a groove communicating with the frontal sinus was found inside the frontal bone. The groove grew shallow upwards and outwards until it ended with an exostosis in the uppermost portion. Apart from destruction in the floor of the frontal sinus a considerable thinning was found in the anterior wall, as well as a defect 2×2 cm in size in the posterior, cerebral wall of the sinus. The mucous membrane of the frontal sinus and ethmoid labyrinth had degenerated due to polyposis.

DIFFERENTIAL DIAGNOSIS BETWEEN VARIOUS FORMS OF ORBITAL INFLAMMATIONS

In establishing the diagnosis great attention should be paid to the case history, particularly to diseases which might have caused subsequent changes in the orbit.

According to the literature and our own observations, these include erysipelatous inflammations of the face and head, furunculosis of the face and brow, as well as traumas which are especially liable to orbital complications.

After these diseases have been ruled out as the etiological factors of the orbital lesion, the patient should be examined for the condition of the nose and paranasal sinuses, since more than 60 per cent

of orbital complications are of rhinogenous origin. In the majority of cases, the past history of the case gives reason to suspect an acute or subacute inflammatory process in the nose and paranasal sinuses, which requires a detailed and comprehensive rhinological examination of the patient.

In certain cases, rhinoscopy alone may be enough to identify an orbital disease. In such cases, pus, polyps and polypous degeneration of the turbinate mucosa are discovered in the middle nasal meatus on the affected side during the examination of the nasal cavity in adults. In addition to rhinoscopic data, acute inflammations of the paranasal sinuses or exacerbations of chronic sinusites are marked by tenderness on pressure applied to the bony walls of the sinuses, such as the frontal sinus in frontal sinusitis, the lacrimal bone or the deeper portions of the internal orbital wall in ethmoiditis, the floor of the canine fossa and the frontal process of the maxilla in highmoritis.

In nurselings the lesion of the orbit is consequent upon the lesion of the ethmoid labyrinth, since the other sinuses have not yet formed at this age. Although rhinoscopic examination of the middle nasal meatus or the olfactory fissure is extremely difficult in children of this age, the degree of affection of the ethmoid cells can be established on the basis of the cyanosis and edema of the upper eyelid, particularly in the middle third, and the profuse mucous discharge from one side of the nose.

Instead of pus in the middle nasal meatus children of older age usually have mucus, which is also seen on the posterior wall of the oropharynx, where it flows from the nasopharynx.

The absence of pathological changes in the nose, however, by no means excludes the possibility of affection of a paranasal sinus, since in the case of mucocele or polyps in the sinuses, for instance, the nose may contain no pus at all. In such cases, the only means of obtaining exhaustive information regarding their condition is an X-ray examination of the sinuses undertaken in addition to rhinoscopy.

The presence of a fistula facilitates diagnosis, since the probe inserted into its open channel and pushed posteriorly will reach into a sinus and touch its bony wall, such as the posterior wall of the frontal sinus.

Apart from simple probing, roentgenography with a probe and fistulography are also advisable.

The detection of sinusitis justifies regarding the orbital disease as a secondary affection of rhinogenous etiology. The diagnosis of orbital complications of rhinogenous origin is thus based on symptoms of a paranasal sinus disease, as well as on those of an orbital lesion.

If a connection between the orbital disease and sinusitis has been established, the above-mentioned symptoms can be used

as the basis for specifying the location and character of both the orbital disease and the site of lesion in a paranasal sinus, i.e., for making a qualitative diagnosis of the inflammatory process.

Identification of these inflammatory and non-inflammatory diseases of the orbit requires of the ophthalmologist to have a knowledge of the semiotics of certain orbital diseases of nonrhinogenous etiology as well.

(a) *Orbital periostitis of rhinogenous origin* has to be differentiated from the other diseases of the orbit, primarily from abscesses, but also from syphilitic and tuberculous periostites of nonrhinogenous etiology.

In common cases of orbital periostitis, suspicion of an abscess can be discarded in the absence of marked local and general reactions, above all in body temperature. An intumescence confined to a limited area of the anterior portion of the bony orbital wall—superior, internal or inferior—will nearly always indicate periostitis. The forms of periostitis developing behind the septum orbitae or exhibiting marked local inflammatory and general symptoms warranting presumption of an orbital abscess are difficult to diagnose.

These forms are rarely found in adults; in children, however, their rate is fairly high. In such cases, the diagnosis can be verified by a follow-up study or during an operation undertaken to evacuate the suspected boil.

Tuberculous periostitis usually originates in the bone marrow, whereas a lesion of the periosteum is a secondary process; that is why we usually associate tuberculous periostitis with extension of a periosteal lesion to the bony tissue and marrow.

The above-mentioned types of periostitis are commonly encountered in young persons. They are primarily confined to the external wall, specifically to its supero-external or infero-external margins, since these portions of very dense tissue are rich in bone marrow. It should be borne in mind, however, that in exceptional cases they may be confined to the other walls of the orbit, and the infection may originate in a paranasal sinus, most frequently in the antrum of Highmore.

The clinical symptoms of the initial stage of tuberculous periostitis, particularly when the process is confined to the orbital margin, are swelling and redness of the eyelids with pain on pressure applied to the orbital margin in this region. A circumscribed abscess next develops, which, if opened, usually turns into a stubborn fistula. Sequestration is followed by cessation of pus discharge and formation of a deep and indrawn scar adherent to the bone and tension and eversion of the upper or lower eyelid.

Thus, the fistula, sequestration and cicatricial ecropion of the eyelids are the most typical signs of tuberculous periostitis, which are important for differential diagnosis.

This process develops only in the presence of an already existing specific bone lesion, and may assume one of the two possible forms. The first and benign form is characterised by a circumscribed and comparatively small area of bone death, a round or oval-shaped defect with even margins and without sclerotic reaction being seen in a far-advanced stage. The second and more severe form is identified by the presence of diffuse, progressive infiltration which is not confined to the bony walls of the orbit, but extends to the adjacent bones. This is why tuberculosis of the orbit may be accompanied by lesions of the cranial arch bones which can be discovered in X-ray photos; these may help identify the nature of the morbid process in the orbit. Sometimes changes in the orbital bones are found to occur simultaneously with calcification of the brain tuberculum.

The diagnosis should be verified by an X-ray examination and photography not only of the cranial bones but also of the chest, as well as by the collection of data on the patient's general condition, such as body temperature, the blood picture, ESR, etc.

Syphilitic periostitis in the orbital bones and in the flat cranial bones is manifested either by a diffuse hyperplastic or a gummatous process. As distinct from tuberculous periostitis, its syphilitic counterpart usually arises in the periosteum, from which it extends to the bony tissue.

According to S.A. Rheinberg, syphilitic ostitis should be considered not as an independent form but rather as the result of the process extending to the compact bone tissue from the periosteum or the bone marrow.

The clinical picture of this type of periostitis varies depending on whether it is confined to the bony edge of the orbit or to the deep portion of the orbital wall, behind the septum orbitae. The former case is marked by a limited swelling and tenderness in the superior orbital margin, whereas periostitis in the deep-lying portion is attended with palpebral edema, exophthalmos and displacement of the eyeball. The typical symptoms of syphilitic periostitis of the orbit are spontaneous pains at night.

Specific foci at the roof of the orbit often cause inflammation of the optic nerve. However, if the morbid process involves the region of the supraorbital fissure, the so-called supraorbital fissure syndrome develops with unilateral ptosis, unmarked exophthalmos, full or partial ophthalmoplegia and neuroparalytic keratitis. The same syndrome is observed in case of a tumour growing into the orbital fissure, and in inflammations of nonspecific etiology.

Since osteosclerosis is the basic symptom in a syphilitic disease of the orbital bones, this process will appear as a diffuse or circumscribed shadow in an X-ray picture. Insofar as similar changes are typical of all the processes developing into a reactive hyperostosis of the bony wall of the orbit, an X-ray picture alone, i.e., without

recourse to clinical data, such as anamnesis, laboratory investigations, including Wassermann's test, will not provide sufficient evidence to establish the nature of the disease. Identification is particularly difficult at an early stage.

In gummatous periostitis, pale areas with a hyperostotic swelling around the focus are seen in the X-ray picture; if, however, the lesion is located near the optic foramen, the latter's contours as well as the margins of the supraorbital fissure will become either more intense in hue as compared to the opposite side, or blurred, the fissure itself being narrower. The gumma often arises on the internal surface of the inferior orbital margin, near the lacrimal sac; such a gumma may be mistaken for a tumour.

(b) *A subperiosteal abscess* should be differentiated from grave forms of orbital periostitis.

In cases of this abscess being confined to the supero-internal corner of the orbit it may be mistaken for a phlegmon of the lacrimal sac. The location of the boil above the internal palpebral ligament, however, would indicate a subperiosteal abscess of rhinogenous etiology, i.e., empyema of the frontal sinus or ethmoid labyrinth, whereas an abscess associated with a lesion of the lacrimal sac will have the boil beneath the internal ligament.

A subperiosteal abscess located at the supero-external margin of the orbit may be caused by pus erupting from the frontal sinus if the latter reaches as far as the external margin of the orbit, and also by abscess formation in the lacrimal gland. In the latter case, traction on the external margin of the upper eyelid will expose the gland bulging into the superior transitional fold.

In the presence of a fistula differential diagnosis is made easier by probing, as well as by X-ray photography after the fistular channel has been filled with contrast substance.

A subperiosteal abscess may also develop from *osteomyelitis of the zygomatic and superior maxillary bones.* The source of the disease may in certain cases be identified only at operation. If in opening the abscess pus is detected extraaponeurotically, i.e., outside the sac containing the soft orbital tissues, such as fat, muscles, vessels and nerves, and it is possible to expose the carious bone unconnected with an empyema in a paranasal sinus, the disease is certainly of osteomyelitic origin.

The fairly common limited swelling of the eyelid and even fluctuation around the superior and internal margins of the orbit are encountered only with *a cystoid distention of the paranasal sinuses, i.e., mucocele.* The absence of inflammatory symptoms in the eyelids and conjunctiva as well as of symptoms characteristic of mucocele is plain evidence against such a diagnosis.

The difference between the subperiosteal abscess of rhinogenous origin and a dermoid is established primarily by X-ray examination.

(c) *Abscesses in the orbital cavity.* An orbital abscess attended with a considerable collateral edema may be mistaken for *Quinke's acute angioneurotic edema.* The latter condition, however, is characterised by intermittent exophthalmos, as well as by the presence of compact, somewhat diffuse nodes behind the eyelids and in the anterior portion of the orbit; such nodes are not encountered in common collateral edema developing around the inflammatory focus (M. J. Averbach).

Differential diagnosis of an abscess and a phlegmon of the orbit is complicated by the fact that identical local and general clinical symptoms are often produced by these conditions; the diagnosis is verified by pressure on the eyeball: the latter moves in any direction in case of an abscess, whereas an orbital phlegmon makes it completely immobile.

(d) It is rather difficult to differentiate between an *orbital phlegmon* and an abscess in the orbital cellular tissue. Differential diagnosis in this case is facilitated by such symptoms as marked constitutional debility, high fever, chills, headaches and other symptoms of septic poisoning, as well as by marked local signs, such as diffuse swelling and redness of the eyelids, particularly marked tension and infiltration in the upper eyelid even to the point of stiffening, and other symptoms, which, taken together, are more indicative of an orbital phlegmon.

The character of eyeball displacement and the limitation of its mobility also aid differentiation, since forward protrusion of the eyeball is a typical feature of an orbital phlegmon, whereas in the case of an abscess the eyeball is displaced to the side opposite to its presumed location.

Moreover, phlegmon is marked by sharp pain on pressure applied to the eyeball, which is not symptomatic of an abscess. A phlegmon may also give rise to edema of the optic nerve sheaths attended with a severe loss of vision, even to the degree of blindness, thrombophlebitis of the retinal veins and even exfoliation of the retina.

It is more difficult to distinguish an incipient phlegmon from a subperiosteal abscess. The diagnosis in this case is therefore based on anamnesis and general examination. Diagnosis is also difficult in cases where the orbital phlegmon arises by extension of a phlegmonous process from the lacrimal sac to the soft tissues of the orbit rather than as a result of empyema in a paranasal sinus.

Such cases are infrequent, however, since the orbital septum is an effective barrier against the extension of infection from the anterior portion of the orbit to the retrobulbar space. X-ray examination of the lacrimal passages helps in the majority of cases to ascertain the nature of the disease. The following case report may serve as an example.

Fig. 20. Phlegmon of the lacrimal sac mistaken for a rhinogenous phlegmon of the orbit. Exophthalmos; limitation of eyeball mobility in all directions; the palpebral fissure is narrowed; the eyelids are edematous. There is a considerable infiltration in the region of the lacrimal sac and the inner half of the lower eyelid

Case report 8. Patient S., female, aged 30, admitted on February 14, 1949, for right-side orbital phlegmon and acute right-side pansinusitis. Right eye closed the day before, and eyelid edematous and red. Physical examination in right eye: lacrimation, abnormally narrow palpebral fissure, palpebral edema, hyperemia of the palpebral skin (Fig. 20). Considerable infiltration in lacrimal sac region and inner half of lower eyelid; skin in this place red and edematous. No discharge from lacrimal puncta on pressure. Exophthalmos; eyeball mobility markedly limited in every direction. Ocular conjunctiva swollen, cornea and other refractive media transparent. Anterior chamber of normal depth. Iris pattern unchanged, ocular fundus having optic disk borders slightly blurred and veins somewhat dilated. Left eye normal.

X-ray examination (Fig. 21) revealed a shadow covering all the paranasal sinuses on the right side and the right orbit. Rhinoscopy revealed no pathology. Body temperature was 38°C. The white and red blood cells were unchanged. Penicillin treatment was undertaken by means of intramuscular injections, as well as sulfonamide (norsulfazol) treatment per os. A week later the phlegmon in the lacrimal sac region burst by pointing, the exophthalmos decreased, the eyeball regained mobility, the body temperature dropped to normal, and this was followed by the closure of the lacrimal sac fistula on March 10.

Thus, we could see that a phlegmonous inflammation in the lacrimal sac region had extended here to the orbital cellular tissue and was mistaken for a sequel of paranasal sinus empyema.

Finally, an orbital phlegmon has a number of signs, such as swelling and edema of the eyelids, direct exophthalmos and venous

hyperemia in the optic disk, that have much in common with the symptoms of thrombophlebitis of the brain sinuses, mainly the cavernous sinus, from which it has, therefore, to be differentiated.

It is necessary to differentiate between primary rhinogenous phlegmons of the orbit complicated by subsequent thrombosis of the brain sinuses and primary thrombosis of the brain sinuses caused by empyema of the paranasal sinuses (usually the sphenoid sinus and rarely the antrum of Highmore), complicated by an orbital phlegmon.

A typical symptom of primary rhinogenous phlegmon of the orbit is a unilateral orbital lesion. The morbid process extends to the other side later, after thrombosis of the cavernous sinus has developed.

A primary thrombophlebitis of the sinus is indicated by a bilateral orbital lesion, severe cerebral symptoms of central origin, such as headache, vertigo, vomiting, delirium, etc., as well as by edema of the temporal region and the mastoid process (emissarium Santorini leads to the sinus transversus, and the latter—to the sinus cavernosus).

(e) *Pseudocholesteatoma* should be differentiated from mucocele, chronic sinusitis and true cholesteatoma.

Inasmuch as mucocele uncomplicated by a sinusal empyema develops without acute inflammatory symptoms, swelling in the cheek and eyelids, and particularly, the presence of a fistula near the alveolar process of the maxilla, always serve as evidence against a cystoid distention of the sinus, even if an X-ray film shows its expansion as a result of displacement of its walls, for instance, of the floor of the frontal sinus to the orbit.

The presence of stratified masses of white cornified epidermal scales suggests either an epidermoid, i.e., true cholesteatoma, or pseudocholesteatoma.

True cholesteatoma is exceedingly rare. Of the 27 cases cited in the literature, some should be classed among inflammatory formations, i.e., pseudocholesteatomata (see Chapter V).

In evaluating each case of cholesteatoma one should remember that this is a rare disease and that a quick aggravation of clinical symptoms, such as swelling of the cheek and eyelids, and the presence of mucopurulent contents in the nose, speak against an epidermoid and in favour of pseudocholesteatoma.

Prognosis. Among all the inflammatory diseases of the orbit, an abscess in the orbital cellular tissue, particularly an orbital phlegmon, is the most severe, threatening not only the organ of vision but also the patient's life. This complication often gives rise to cavernous sinus thrombosis and intracranial processes. According to S. V. Ochapovsky's summary data, the death rate for this disease may reach 29 per cent and the rate of vision disorders 33 per cent. According to Birch-Hirschfeld, a fatal outcome

was observed in 54 out of 409 cases of various orbital complications, i.e., 13.2 per cent, the rates of individual lesions being as follows: lesions of the sphenoid sinus—28 per cent, lesions of the maxillary sinus—19.6 per cent, lesions of the frontal sinus—16.3 per cent, and, finally, lesions of the ethmoid labyrinth—6 per cent. So far as the optic functions are concerned, 66 patients (16 per cent) had prolonged amaurosis, and 50 patients (12.2 per cent) had transient disorders of vision. The immediate cause of these symptoms was a lesion of the optic nerve itself, edema of the perineural membranes, various diseases of the ocular vascular system, thrombophlebitis of the retinal vein, detachment of the retina, hemorrhage, panophthalmitis, and even glaucoma.

These complications usually followed diseases of the antrum of Highmore (27.2 per cent) and, less frequently, those of the frontal sinus (6.5 per cent).

According to S. I. Talkovsky, mortality from orbital phlegmons of various etiology stood at 18.5 per cent, the disease being mainly of rhinogenous origin.

This is how matters stood before the introduction of sulfonamides and penicillin. Today, a lethal outcome in this disease should be regarded as an exception.

Timely and rational antibiotic treatment can not only substantially change and shorten the course of the disease, but also improve its outlook.

In some cases of empyema of the paranasal sinuses complicated by collateral edema of the orbital cellular tissue, penicillin therapy permits elimination of morbid signs in the orbit in a very short time (5 to 7 days) without recourse to surgery.

Treatment. Discussing the treatment of orbital diseases, phlegmons of the orbit in particular, F. F. Ghermann wrote: "...an ophthalmologist should remember that he usually deals with a consequential disease in the orbit, i.e., with the final link in a chain of pathological symptoms, which, viewed in retrospect, can indicate the way to speedy and effective assistance not only quo ad visum but often quo ad vitam as well."

Today, F. F. Ghermann's statement is valid only to the extent that the ophthalmologist should not overlook the importance of attention to the paranasal sinuses as the major morbid focus, whose development may result in sepsis, meningitis, thrombophlebitis of the cavernous sinus and other severe complications.

The question whether one should confine oneself to treatment of the paranasal sinus disease or undertake simultaneously an active treatment of the orbital disease in the event of a rhinogenous lesion of the orbit, is settled today in favour of a complex approach to the treatment of the orbito-sinual region.

The treatment of lesions of the paranasal sinuses and their orbital complications has certain features peculiar to the nature of the

orbital lesion, which gives reason to describe the principles of complex treatment in relation to such lesion.

In simple periostitis caused by a pathological process in the paranasal sinuses the first requirement is conservative treatment.

Physiotherapeutic procedures, such as UHF therapy, diathermy, etc., as well as painting the nasal mucosa with cocaine-adrenalin or dicaine solutions (Sol. Cocaini hydrochlorici 5-10 per cent 10.0 and Sol. Adrenalini hydrochlorici 1:1000—gtt. X; Sol. Dicaini 3 per cent) will eliminate the perifocal symptoms (collateral edema) nearly always attendant on periostitis, and will often contribute to a marked improvement in the condition, if not to a return to normalcy. In acute forms of periostitis UHF therapy is indicated. The method is as follows: an oval-shaped active electrode, 4×7 cm in size, is placed 1.5-2 cm in front of the affected orbital wall; the round-shaped indifferent electrode, 6 cm in diameter, is set 4 to 5 cm before the ear on the affected side. The duration of each session is 8 to 15 minutes; the amount of generated heat is little. The total course consists of 6 to 16 sessions, the first 3 or 4 sessions being given daily, and the remaining sessions—every other day.

In cases where periostitis is attended with inflammation of the retrobulbar cellular tissue, the active electrode is placed at a distance of 3 cm from the eyeball.

Below is a case report of successful treatment of orbital periostitis.

Case report 9. Patient N., male, aged 14, hospitalised for right-side orbital abscess of rhinogenous origin. Disease in progress for five months, in past two weeks with fever rising to 39.5°C and dropping to chills; general malaise and swollen eyelids on right side. Physical examination of right eye: eyelids, particularly upper eyelid, swollen and reddened. Eyeball displaced down and outwards. Slight exophthalmos. Cornea transparent; anterior chamber of medium depth. Pupil of regular form and reactive to light. Ocular fundus accessible to ophthalmoscopy. Acuity of vision 1.0. Left eye normal. Within the nose a purulent streak and polypous degeneration in right middle meatus; at left, polyps. Blood picture as follows: leuk. 19,300, erythr. 1 per cent, band cells 6 per cent, segmented cells 75 per cent, lymph. 12 per cent, mon. 6 per cent. The X-ray film had a shadow in place of the entire right orbit, part of the right frontal sinus, the right-side anterior ethmoid cells, and the right maxillary sinus, all of which indicated right-side pansinusitis.

The treatment was by means of intramuscular and retrobulbar injections of penicillin in 4,000,000 and 10,000 unit doses respectively as well as peroral administration of norsulfazol. The nose was simultaneously packed with a 3 per cent sol. dicaini on pledgets, and the internal wall of the right orbit was subjected to UHF therapy.

At the time of discharge from hospital, the temperature was normal, the right eyeball had returned to its normal place, the swelling of the eyelids had subsided, and the patient's general condition was good.

In periostitis with a chronic course diathermy is preferable. The procedure is as follows: an oval-shaped lead electrode, size

4×5 cm, is placed on the orbital region corresponding to the morbid focus, while the indifferent electrode is placed on the back of the neck. The strength of the current varies from 0.4 to 0.6 A; the duration of a session is 15 to 20 minutes. The total number of sessions held daily or every other day may amount to 30.

The radical, i.e., surgical, treatment of paranasal sinus diseases should be undertaken only in rare cases, such as inflammatory changes in the soft orbital tissues which cannot be reversed otherwise, and collateral or perifocal edema along the periphery of the periosteal focus. Endonasal surgery is required in these cases, such as removal of polyps, resection of the hypertrophied part of the middle nasal turbinate, opening of the ethmoid cells, etc. In addition to penicillin therapy and cocainisation of the nasal mucosa, endonasal surgery is also recommended for *abscesses in the orbital cellular tissue and subperiosteal abscesses* at their initial stage when fluctuation is still absent and the process has not yet become delimited.

The view has been expressed that in the case of a marked retrobulbar or subperiosteal abscess, even at the initial stage, the opening of the orbit should be undertaken in addition to endonasal surgery. For a retrobulbar abscess this consists in a broad bone incision along the internal orbital margin without opening the tarso-orbital fascia and with separation of a considerable portion of the periorbit (subperiosteal orbitotomy); if a retrobulbar abscess is suspected it is necessary to open the septum orbitae and then dig into the retrobulbar tissue without affecting the rectus muscles and evacuate the boil.

The surgical treatment of orbital complications, designed to drain the secondary suppurative focus in the presence of an active principal boil in the paranasal sinus, cannot by itself guarantee against relapses in the orbit.

One should bear in mind in such cases that the orbit and the paranasal sinuses are likely sites for the basic and initial foci.

The nature of surgical intervention on the paranasal sinus largely depends on the location of the primary inflammatory process. If a connection has been established with the frontal sinus and the ethmoid labyrinth, the procedure is comparatively simple, since Killian's arched incision along the brow permits an approach to the periosteum and the tarso-orbital fascia. The matter is altogether different in regard to the maxillary sinus, which should be opened from the side of the vestibulum oris by an incision in the gingiva. These standard operations should be supplemented by external incisions along the margin of the orbital floor, i.e., by orbitotomy. For example, in cases of a deep-seated abscess, a considerable length of the periorbit must frequently be separated from the orbital floor. Some foreign specialists recommend limitation of surgical interference to the maxillary sinus, from where the orbital floor may be opened. This interference, however, as well

as inferior orbitotomy without the opening of the maxillary sinus as recommended by other foreign specialists, is usually abortive. One must therefore agree with the view of S. S. Golovin, A. N. Murzin et al. that the best effect is obtained when marginal orbitotomy is performed simultaneously with the opening of the paranasal sinus.

The case report below shows that orbitotomy alone is not enough to cure orbital suppurations of rhinogenous origin, and that an operation on the paranasal sinuses should be undertaken simultaneously or shortly after orbitotomy.

Case report 10. Patient T., male, aged 68, hospitalised for orbital phlegmon. Complaints of long-standing right-side highmoritis. Thirty years old fistula discharging pus on right-side upper gingiva.

Examination of right eye: marked edema of both eyelids; full closure of palpebral fissure; marked exophthalmos and limitation of eyeball mobility; chemosis of bulbar conjunctiva; partial necrosis of conjunctiva in supero-external quadrant, small quantity of greyish-green pus of abhorrent fetor; dull cornea; slightly dilated pupil; hardly visible pink reflex of ocular fundus.

X-ray photography of the paranasal sinuses showed the right frontal sinus to be of considerable size, extending outwards to the supero-external margin of the orbit and having indistinct outlines. The interfrontal septum was markedly displaced to the left. The transparency of the sinus was irregular, with air contained in its depth. The frontal bone wall bordering on the superior margin of the frontal sinus appeared somewhat blurred. The ethmoid cells at right had decreased transparency. There was a perimural entumescence in the right and a dark shadow in the left maxillary sinus. The right orbit was darkened, with a bone defect in its superior wall on the border between its middle and inner thirds.

Inside the nose a polypous degeneration of the middle turbinate was discovered on the right side and pus in the middle meatus on the left side.

The patient was subjected to urgent orbitotomy: the tarso-orbital fascia was opened extensively, but no pus appeared until the defect in the conjunctival arch was broadened (closer to its external portion).

In spite of the orbitotomy performed under penicillin cover no drastic changes occurred in the patient's condition. In view of this, a radical operation on the right frontal sinus and on the ethmoid cells on the same side was undertaken five days after orbitotomy. The sinus proved to be very large: outwardly, it had reached the zygomatic process and invaded the left side. Its floor was found to have a small defect and the sinus itself to contain a cramby and pasty mass. Polyposis was discovered in the cells of the ethmoid labyrinth. The patient was discharged in good shape within a fortnight. The eye could be opened, but the right upper eyelid could not yet be lifted. Diplopia was absent.

In the case of an orbital complication in a child the choice of surgical procedures depends on the patient's age, which has a bearing on the process of sinus formation (see Chapter I.) For example, at the age of 7 to 8, when the milk teeth have not yet been replaced

by permanent teeth, the maxillary sinus should not be opened through the gingiva to avoid destruction of the rudiments of the permanent teeth. For the treatment of osteomyelitis of the superior maxillary bone, which is frequently the cause of orbital complications in children under 5, it is enough to cleanse the bone around the follicles of the alveolar process; no attempts at penetrating into the maxillary sinus are recommended. For nurselings it is enough to make an incision along the inferior edge of the orbit, to separate and elevate the tissues of the frontal (facial) wall until the infraorbital foramen is exposed; the fistula often encountered in children of this age at the inferior orbital margin calls for interference of this particular kind. It is advisable to open the ethmoid labyrinth simultaneously with an operation on the frontal or maxillary sinus. In cases of foci located deep in the orbit, the latter's intranasal opening is contraindicated.

The treatment of orbital phlegmons should be started with intramuscular penicillin injections in large doses coupled with simultaneous surgical interference. Instead of multiple small but deep incisions of the type used formerly, the usual procedure today is subperiosteal marginal orbitotomy which, upon separation of the periosteum from the internal surface of the orbit, is followed by a large sagittal incision made in the latter, whereupon the orbital cellular tissue is pushed apart, preferably with the finger, and the orbital cavity is packed with a gauze strip, its end being left outside.

Among the forms of extensive surgical interference the most radical for an orbital phlegmon or an abscess in the retrobulbar tissue is osteoplastic orbitotomy, and in case of the loss of vision—orbitosinual exenteration of the orbit after S. S. Golovin. These methods may facilitate a detailed examination of the affected area, a prolonged drainage of the sinual wound (S. S. Golovin's method), and may avert the danger of an intracranial complication.

Today the use of antibiotics and sulfonamides has largely lessened the need for Krönlein's and S. S. Golovin's operations for phlegmons of the orbit.

The only rational and radical method of treatment of *orbital pseudocholesteatoma* is the surgical opening of the foci in the paranasal sinus and the orbit. Apart from the usual rhinological procedures in opening the sinuses (see Chapter VII) additional incisions have sometimes to be made, co-extensive with the pseudocholesteatoma.

For most inflammatory diseases of the orbit caused by empyemas in the paranasal sinuses, surgical treatment is ordinarily used in combination with sulfonamide and antibiotic administrations to speed recovery and reduce the rate of postoperative complications.

The commonly used antibiotics are penicillin, streptomycin, biomycin, terramycin, tetracycline, levomycetin, and synthomycin.

Since indications for the use and dosage of these drugs are widely known, we need not dwell on this subject.

IV

Mucocele

(Cystoid Distentions of the Paranasal Sinuses)

"If we have to deal with a slowly growing exophthalmos, particularly with an eye displacement outwards or down- and outwards an absence of indisputable signs of an orbital phlegmon will indicate a lesion of the paranasal sinuses, even if complaints and endonasal examination data are inadequate for this conclusion" (M. I. Averbach).

A considerable proportion of lesions of the paranasal sinuses affecting the organ of vision are caused by mucocele, a peculiar process producing distention of the sinus by obstruction of its natural orifice and accumulation of secretion.

The wide introduction of modern X-ray techniques has largely facilitated the diagnosis of this condition, which used to be quite a problem in the past.

This is illustrated by the following data furnished by the Helmholtz Institute of Ophthalmology. During the 35 years of existence of the Alekseyev Eye Clinic (prior to its reorganisation as a research institute) 26 cases received treatment for mucocele at its in-patient department, whereas between 1946 and 1955, that is in ten years, as many as 20 patients were operated upon.

This disease attracts the interest of both ophthalmologists who are usually first asked for treatment, and rhinologists to whom the surgical interference is usually entrusted.

An outstanding contribution to the study of this disease was made by S. S. Golovin, who reported on cystoid formations extending into the orbit from the adjacent sinuses as far back as 1895, i.e., five years before the prominent German rhinologist Killian who, having made no case studies of his own, compiled a survey on mucocele based exclusively on 64 cases collected from literature.

S. S. Golovin, continuing to collect data on mucocele, presented to the 12th International Congress of Ophthalmologists in 1914 a detailed report on the clinical picture, surgical treatment and pathological anatomy of this disease.

ETIOLOGY AND PATHOGENESIS

Our knowledge of the etiology and pathogenesis of mucocele is now sufficiently complete. The consensus of opinion is that its major causative factor is obstruction of the mouth or the whole of the natural orifice of the paranasal sinus.

The causes of this obstruction are still a subject of controversy. Some believe that it is associated with anatomical variants, others refer to maldevelopment, still others maintain that obstruction of the natural orifice or its mouth is caused by inflammatory changes in the nasal mucosa, polyposis and its sequels, as well as by factors liable to produce constriction or full closure of the duct lumen, cicatricial changes in syphilis, scleroma, etc. The sequels of injuries, which may directly cause a mucocele or accelerate the existing process, as well as operations earlier made on the frontal sinuses may also be listed among them.

Cysts in the paranasal sinuses have become more frequent of late, which fact is attributed by Schubert and Decher (1957) to incomplete recovery from sinusitis relapsing into a chronic form with closure of the natural orifice following antibiotic treatment.

The development of mucocele may be described as obstruction of the mouth of the natural orifice of the sinus followed by superfluous accumulation of mucoid liquid of noninflammatory character, which forms continually. Later the liquid compressed in the paranasal sinus begins to press on its mucous membrane and bony walls. As a result of the growing pressure the orbital walls, usually the superior (roof) and the internal, begin to atrophy, grow thin and partially resolve. Unresisted by the thinned-out walls of the sinus the mucocele spreads towards the orbit, pushing before it the pliable bony wall, and the sinus extends to a size where it can hold up to 300 cu cm of liquid and more. The same processes of atrophy and resorption of bony tissue are found in the other sinus walls; for example, in the posterior and even the anterior wall, as is observed in a frontal sinus mucocele. These processes, however, are particularly manifest on the orbital wall of the sinus.

PATHOLOGICAL ANATOMY

The pathological changes in the paranasal sinuses with a mucocele have been studied in Russia by S. S. Golovin, V. I. Voyachek, P. N. Kartashev, A. G. Fein, A. G. Likhachev, to mention a few.

Since the early diagnosis of mucocele is extremely difficult, the primary microscopical changes in the paranasal sinus mucosa are still obscure. However, when the clinical picture is sufficiently obvious and the process has grown beyond the sinus limits, changes in the mucous membrane are found in addition to rough lesions in its bony walls, even with complete resorption of bony tissue.

Fig. 29. Protrusion and displacement of the left eyeball down- and outwards. A round swelling is seen at the superointernal angle of the orbit, above the internal palpebral ligament and under the middle third of the eyebrow. The swelling is dense and somewhat tuberous on palpation. The eyeball mobility is disturbed

The changes in the mucous membrane produce a picture of chronic inflammation and necrosis in the epithelial layer and formation of connective tissue in the deeper portions. In a far-extended sinus, the mucosa is thin, atrophic and pale. The superficial epithelium is partly infiltrated, partly absent and in some parts squamous through metaplasia. The connective tissue portions are found to contain microcellular infiltration, newly-grown areolar granulation tissue, and dilated vessels. The glands are absent.

Case report 11. Patient T., female, aged 33. Left eye displaced outwards six months ago. On examination protrusion and displacement of left eyeball down- and outwards. Distance between middle of nasal bridge and inner palpebral ligament greater at left than at right (Fig. 29). In supero-internal corner of orbit, above internal palpebral ligament and under middle third of eyebrow round swelling of dense consistency and somewhat tuberous felt by finger palpation. Eyeball mobility disturbed. Lacrimal passages and conjunctiva normal, refractive media transparent; ocular fundus without pathological changes. Acuity of vision in right eye 1.0. Rhinoscopical examination revealed nothing extraordinary. X-ray photography showed distention of the left frontal sinus, the septum between both sinuses being displaced to the right and the floor of the left sinus displaced downwards, towards the orbit; the internal wall of the left orbit was also pushed into the orbital cavity; the ethmoid labyrinth was shadowed (Fig. 25).

It was found at operation that the anterior bony wall of the frontal sinus was markedly atrophied, the sinus floor had a bone defect with a cyst protruding into the orbital cavity; the internal wall of the left orbit was completely destroyed. The cyst occupied the left frontal sinus and all the cells of the

ethmoid labyrinth and contained a pale, viscid liquid. The cyst capsule had thinned-out walls, and its contents harboured non-hemolytic staphylococci.

Histological examination revealed a mucous membrane coated with epithelium only in a small portion, which is a typical feature of columnar epithelium. In many places it was a cuboidal or squamous unilaminar epithelium, but in a still larger area it was absent altogether. This was particularly evident, where the underlying tissue was indurated by sclerosis beginning in the superficial layers. In the places where the epithelium remained, the mucous membrane was infiltrated by leukocytes and a small number of plasma cells: the number of histiocytic cells was also increased. In most spots the infiltration was diffuse. The lymphatic spaces and blood vessels in the infiltrated areas were dilated (K. I. Golubeva).

The postoperative course was normal. Following the operation the left eyeball moved back into place.

An extensive study of the morphology of bone changes has been made by S. S. Golovin. Examining the external connective tissue layer of the mucocele capsule pressed against the bony walls of the sinus, he discovered within its depth not only epithelial cells detached as a result of connective tissue growth, but also laminae of atrophied bone, which had turned into a structureless tissue. From this he drew the conclusion that the death of bone corpuscles proceeded from inside outwards and led to the destruction of the bony walls of the paranasal sinus. Despite the atrophy and destruction of the bony walls under the periosteum, coating the orbital surface of the paranasal sinus wall, the boneforming function of the periosteum becomes more intensive. The "bony crown", "osteophytes", along the margins of the orbital wall defect are regarded in clinical practice as one of the basic clues to diagnosis.

The mucocele capsule is formed of the inflamed mucous membrane of the paranasal sinus which turns into a closed sac.

The cyst contents are pale or grayish-yellow, opalescent or amber-coloured, viscid, odourless liquid; sometimes it is a thick, albuminous mass resembling soft jelly. A yellow, brown or chocolate colour of the slime is due to the presence of changed blood pigments.

Chemically, the slime is composed of mucin, cholesterin and fat. Its microscopical studies indicate the presence of squamous and ciliated epithelial cells, leukocytes (neutrophils), whereas its staining after Gram and Giemsa reveals a picture of purulent disintegration. In bacteriological investigation the slime is nearly always found to be sterile.

CLINICAL SYMPTOMS

The favourite site of mucocele is usually the frontal sinus; much less frequently the cyst develops in the ethmoid labyrinth. Having originated in one of these structures, a mucocele rarely, if ever,

confines itself to one sinus. As the bony walls thin down and resolve, it tends to extend to an adjacent sinus, for instance, from the frontal sinus to the ethmoid labyrinth, and in case the primary focus is in the labyrinth—to the frontal or sphenoid sinus, less frequently to both sinuses simultaneously.

Therefore, in cases with marked clinical symptoms a mucocele invading two or even three sinuses is usually discovered at operation.

The disease is commonly encountered between the age of 11 to 20, and relatively seldom at a younger age, before 10, or between 50 and 60.

Its course is slow, covering years or even decades. No symptoms come on until the cyst grows beyond the paranasal sinus; even in clinically marked cases without such complications as pyocele, inflammatory symptoms in the cyst and along its periphery are usually absent.

The clinical symptoms of mucocele appear even before the bony walls of the paranasal sinus resolve under pressure from the growing cyst. In the early stages of the disease, a small swelling can be discovered at the inner orbital angle or under the upper orbital margin, in its middle third. If the bony wall is atrophied and consequently pliant and somewhat sunken down or outwards, an elastic, resilient obstacle is felt on pressure applied to it. The sound produced by finger palpation resembles that heard in crepitation or parchment-crackling or, as some authors write, the sound heard in pressure on a tin; the skin covering the cyst is not changed or adherent to it.

Sometimes it is possible to reduce the cyst in size by pressing it towards the paranasal sinus, which indicates the presence of a bone defect in the orbital wall of the sinus and a hernioid protrusion of the mucocele through this defect. Careful finger palpation sometimes makes it possible to identify the edges of the defect, which appear as a bony torus, "bony crown" or individual bony outgrowths, osteophytes, which are a valuable diagnostic sign of mucocele.

As the mucocele grows in size and considerably destroys the orbital wall of the sinus the hernioid protrusion becomes quite apparent to the examiner, who can determine its fluctuation by finger palpation.

The destruction of the bony walls of the orbit and mechanical pressure of the mucocele on the orbital contents affect primarily the position of the eyeball. A prominent symptom in such cases is its protrusion and displacement to one or the other side, depending on which sinus is affected.

These changes are typical of a mucocele with marked clinical symptoms.

The limitation of eyeball mobility is caused either by purely mechanical factors, such as direct pressure of the cyst on the

eyeball, or by affection of the neuromuscular apparatus as a result of compression of the nerve branches leading to the eyeball or eyelids.

The literature describes cases of ptosis of the upper eyelid caused by pressure of the mucocele on the oculomotor nerve, cases of disturbed reaction of the pupil to light, convergence due to compression of the ciliary ganglion, and other symptoms.

Among exceedingly rare complications is edema of the eyelids and forehead as a result of compression of the draining veins of the orbit, as well as keratitis, orbital phlegmons, abscesses, the shrinking of the field of vision and diplopia.

The refractive media and optic function do not, as a rule, suffer in mucocele. The impairment of vision observed in some cases is caused by refraction anomaly rather than by mucocele.

The frontal sinus. Sometimes, the patient complains of headaches long before the outward symptoms of mucocele in the frontal sinus become apparent. This is regarded by certain medical authors as an early sign of the disease. This view may be true with regard to isolated cases where the mucocele extends not so much towards the orbit as to the posterior wall of the frontal sinus and the frontal lobes of the brain, and therefore produces no symptoms in the orbit.

In the majority of cases of frontal sinus mucocele, exophthalmos is its only sign when the patient applies for medical aid.

In a more or less plain form of mucocele in the frontal or fronto-ethmoidal region, the palpebral fissure on the affected side lies lower than that on the normal side. Examination with an exophthalmometer shows that the eyeball protrudes 4 to 5 mm and more, and is also displaced downwards or down- and outwards 10° to 15°, which, in addition, is quite often attended with limitation of eyeball movements upwards and inwards, i.e., towards the site of the mucocele.

Given below is a report on a mucocele in the frontal sinus and ethmoid labyrinth.

Case report 12. Patient B., female, aged 20, hospitalised on February 5, 1949, for mucocele in left frontal sinus and ethmoid labyrinth. Eight years previously protrusion of left eye presumably due to severe contusion four years before onset of exophthalmos. Palpebral fissure lower at left than at right. Under upper orbital margin a swelling, dense and painless on finger palpation. Palpebral skin unchanged, lacrimal organs normal, eyeball prominent and displaced down- and outwards (Fig. 30), its movements upwards and outwards limited. Eyelid and eyeball mucosa unchanged, cornea transparent and lustrous. Anterior chamber of medium depth, iris pattern clear. Pupil of regular form, with good reaction to light. Crystalline lense and vitreous body transparent. Ocular fundus without pathological changes. Acuity of vision 1.0. Right eye normal.

Rhinoscopy revealed a polypus obliterating the left side of the nose.

Fig. 30. Mucocele of the left-side frontal sinus and ethmoid labyrinth. Exophthalmos and displacement of the left eyeball down- and outwards: the left palpebral fissure is lower than the right

X-ray examination disclosed distention of the left frontal sinus. Its floor being undifferentiable, the internal wall of the left orbit destroyed, the left ethmoid labyrinth shadowed partially and the left maxillary sinus clouded at the wall (Fig. 26).

The diagnosis of mucocele was confirmed and substantial destruction of the roof and internal wall of the left orbit was discovered at operation. A fortnight after the operation the left eyeball began a gradual return to its normal place.

Sometimes the palpation of the swollen region helps to reveal an atrophied and depressed supero-internal orbital wall or a defect therein. The presence of a defect may be inferred from the fact that the mucocele can be pushed or pressed into the frontal sinus, or from the presence of a bony torus, or "crown", formed round the edges of the defect.

Diplopia caused by displacement of the trochlear and subsequent changes, paresis and paralysis of the superior obliquus or rectus muscles is rarely encountered, and only with mucocele of the fronto-ethmoidal region.

Given below is an observation where diplopia and lacrimation caused by a cystoid distension of the fronto-ethmoidal region disappeared following surgical interference.

Case report 13. Patient K., female, aged 48, hospitalised for a year-old right-side fronto-orbital tumour. At onset pain in right eye, the latter "blood-

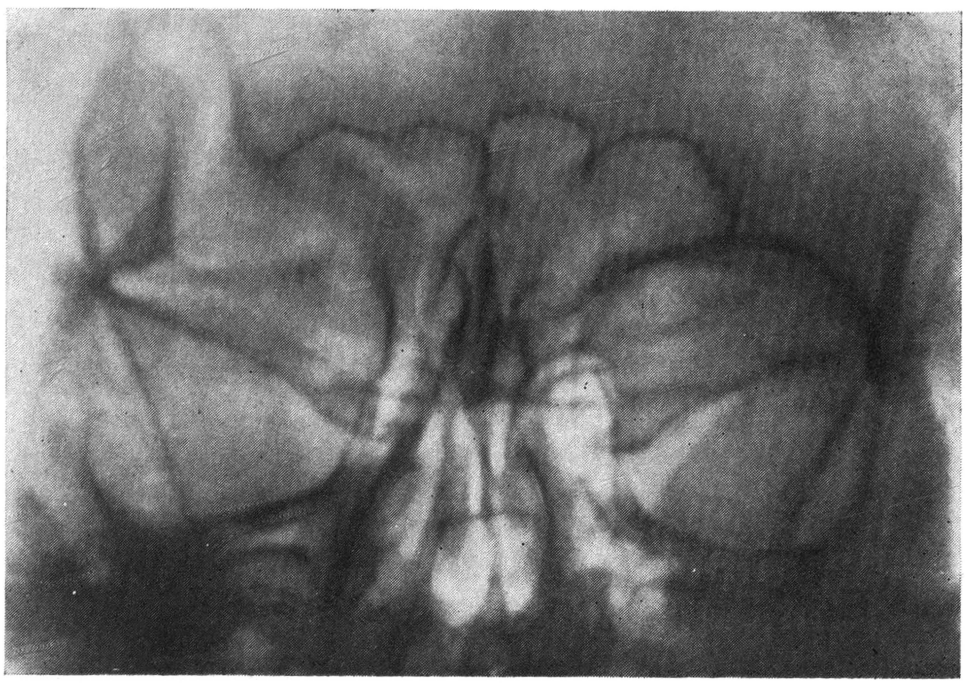


Fig. 24. Cholesteatoma of the right frontal sinus and orbit. The defect in the right frontal bone is shaped as a wide fissure with perfectly smooth and even edges; fissure begins in the frontal bone 3.5 cm from the supraorbital margin, where it somewhat expands, the defect involving the middle third of the supraorbital margin. The fissure opens into a sac with clearly defined and indurated borders. The sac also extends to the inferio-external region of the right frontal sinus

Fig. 25. The same case as in Fig. 29. The X-ray film shows distention of the left-side frontal sinus. The interfrontal septum is displaced to the right; the floor of the left frontal sinus is depressed to the orbit; the internal wall of the left orbit is slightly differentiable, and is also displaced into the orbital cavity; the ethmoid labyrinth is shadowed. Diagnosis: mucocele of the left frontal sinus and ethmoid labyrinth

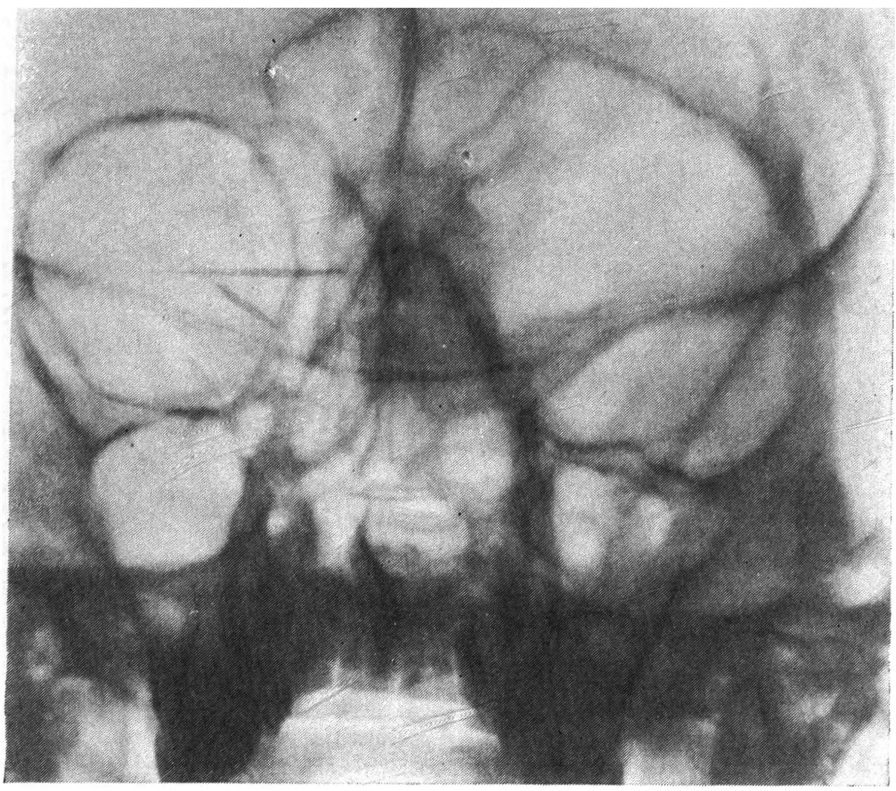


Fig. 26. The same case as in Fig. 30. Ectasia of the left frontal sinus. The sinus floor is undifferentiable; the internal wall of the left orbit is destroyed; the left-side ethmoid labyrinth is partially shadowed. There is a perimural shadow in the left maxillary sinus

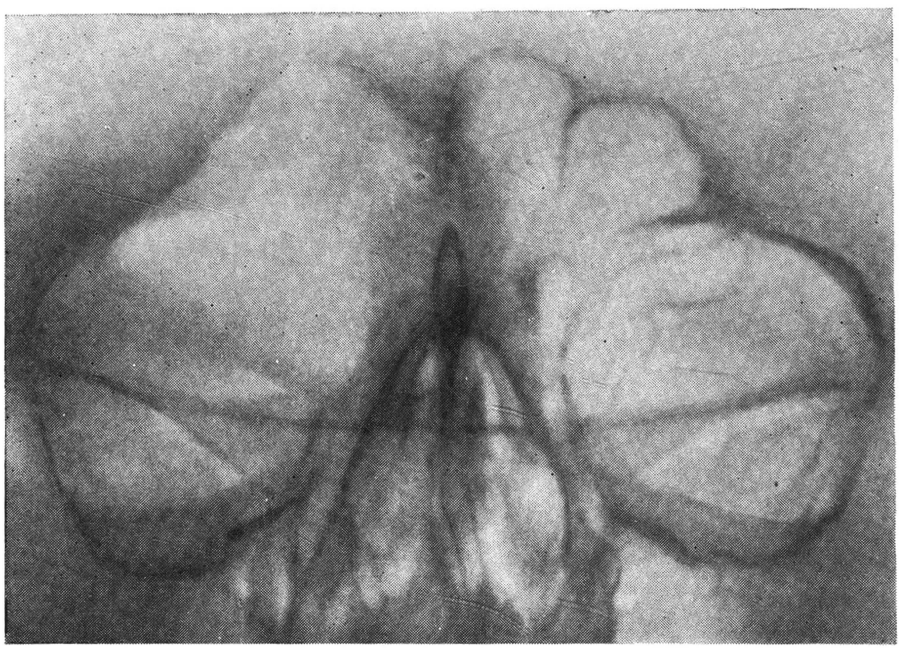


Fig. 27. The same case as in Fig. 31. Complete destruction of the roof of the right orbit. Coalescence of the frontal sinus and orbit at right. The supero-internal and supero-external portions of the right frontal sinus are obliterated. The interfrontal septum is undifferentiable. The process extends from the right to the left frontal sinus. X-ray diagnosis: mucocele of the right-side frontal sinus

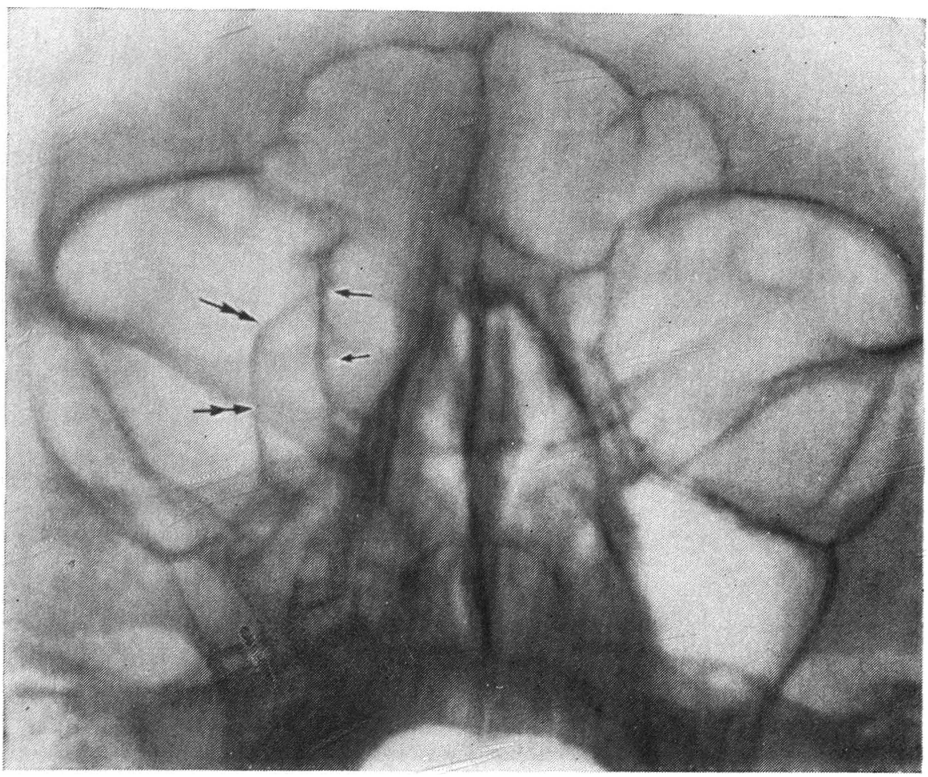


Fig. 28. Mucocele of the right-side ethmoid labyrinth. Distention of the right ethmoid labyrinth (the displacement of the external labyrinthine wall into the orbital cavity is indicated by arrows). A cyst the size of a walnut with a very thin sac is projected in the region of the ethmoid labyrinth and the inner third of the right orbit (double arrows). Clinical signs: exophthalmos and a round elastic formation at the inner canthus under the internal palpebral ligament of the right eye. The diagnosis of mucocele has been confirmed at operation

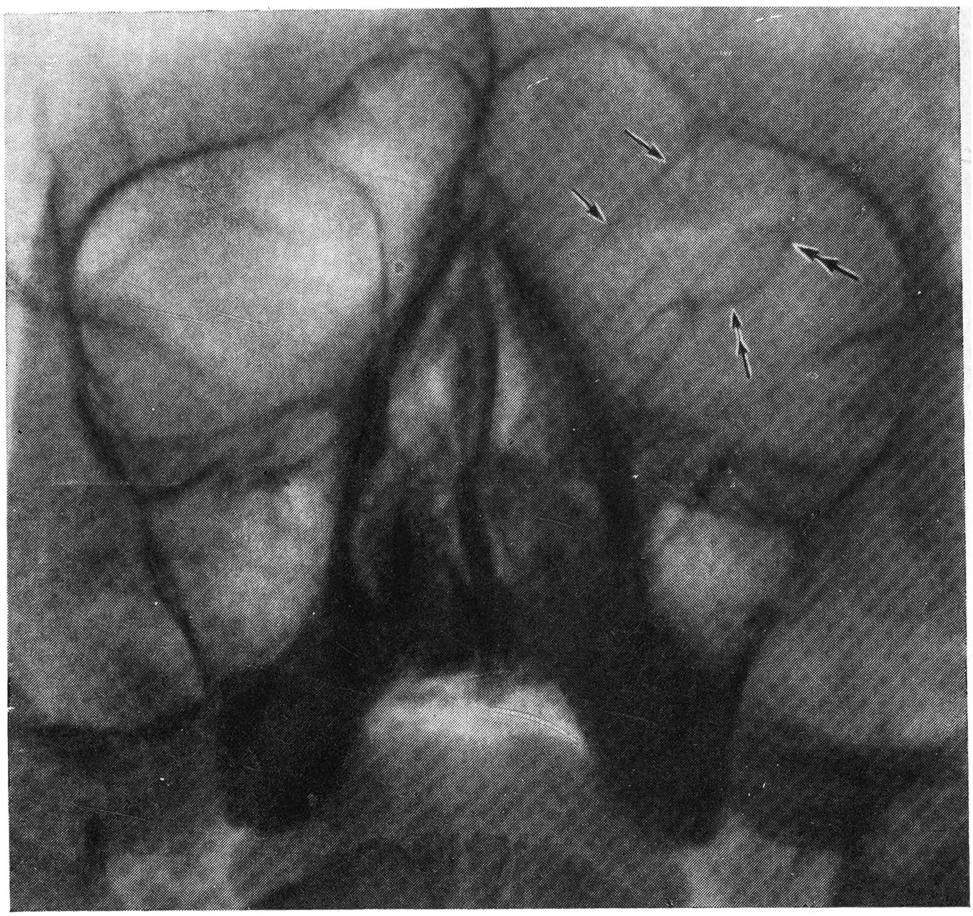


Fig. 33. Mucocele of the left-side frontal sinus. Distention of the left frontal sinus. The sinus floor is atrophied and depressed towards the orbit (see arrows); the contours of the cyst sac and the middle third of the orbit are visible (indicated by double arrows). Clinical signs: the left palpebral fissure is lower than the right; exophthalmos; downward displacement of the eyeball. A swelling of tuberous consistency is felt on palpation at the inner angle of the orbit, and there is a defect under the supraorbital margin, in its middle third. The diagnosis of mucocele has been confirmed at operation

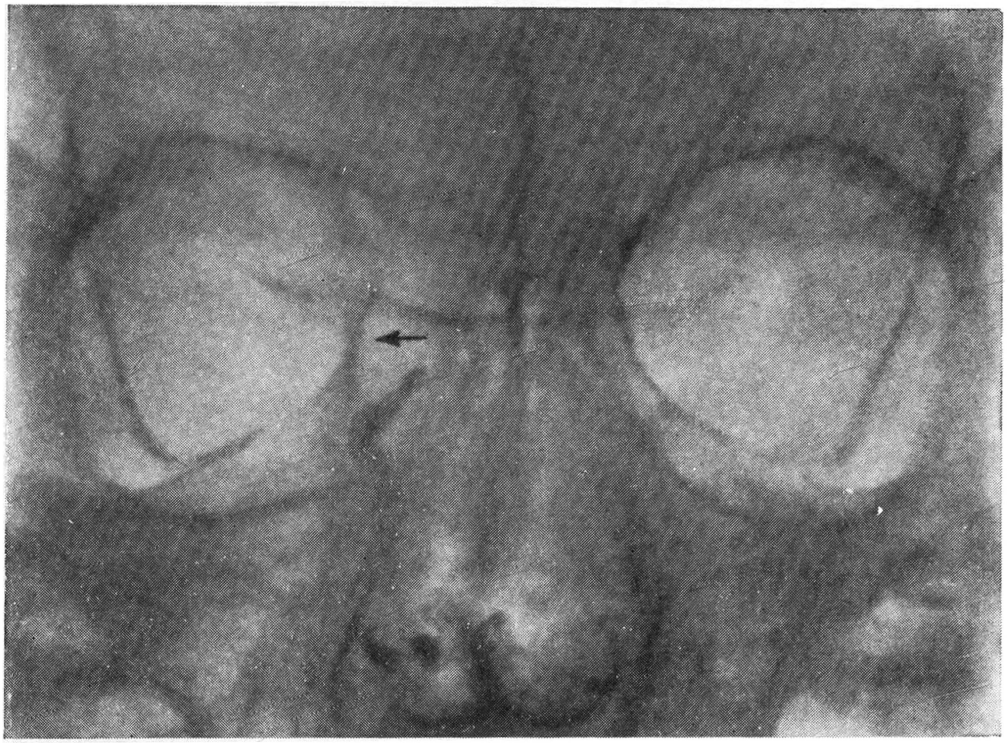


Fig. 34. Mucocele of the right-side ethmoid labyrinth. The labyrinth is a fairly large structureless cavity, the papyraceous lamina being displaced to the orbit (see arrow). The supero-internal boundary of the right orbit is depressed down- and outwards. Clinical signs: a dense and elastic swelling of the lacrimal sac on the right side. The contrast medium introduced into the lacrimal sac finds its way into the nose. The diagnosis of mucocele has been confirmed at operation. The primary diagnosis on admittance to hospital was one of a dermoid cyst

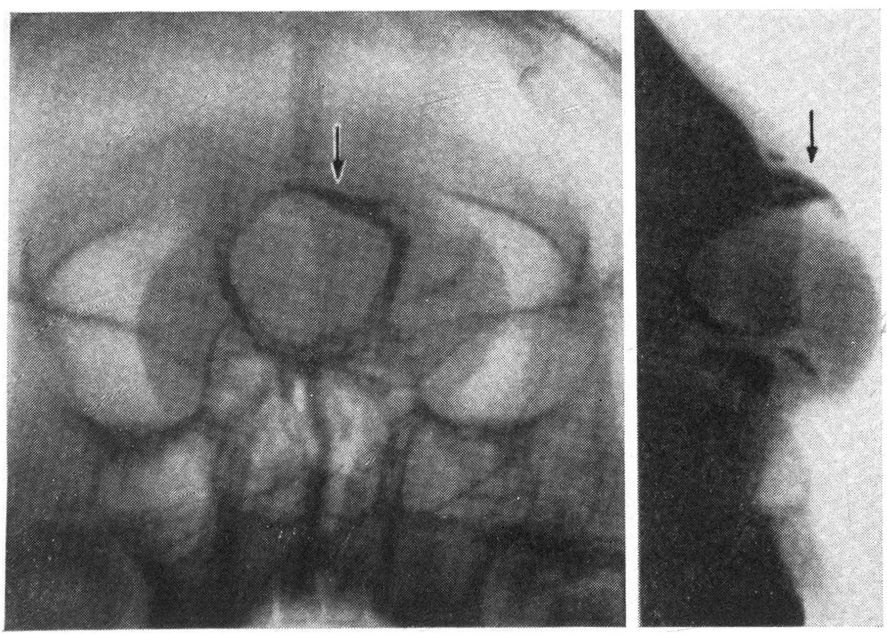


Fig. 35. Naso-frontal brain hernia with a characteristic bone defect and "peaks" above soft tissues indicated by arrows (M. B. Kopylov's report)

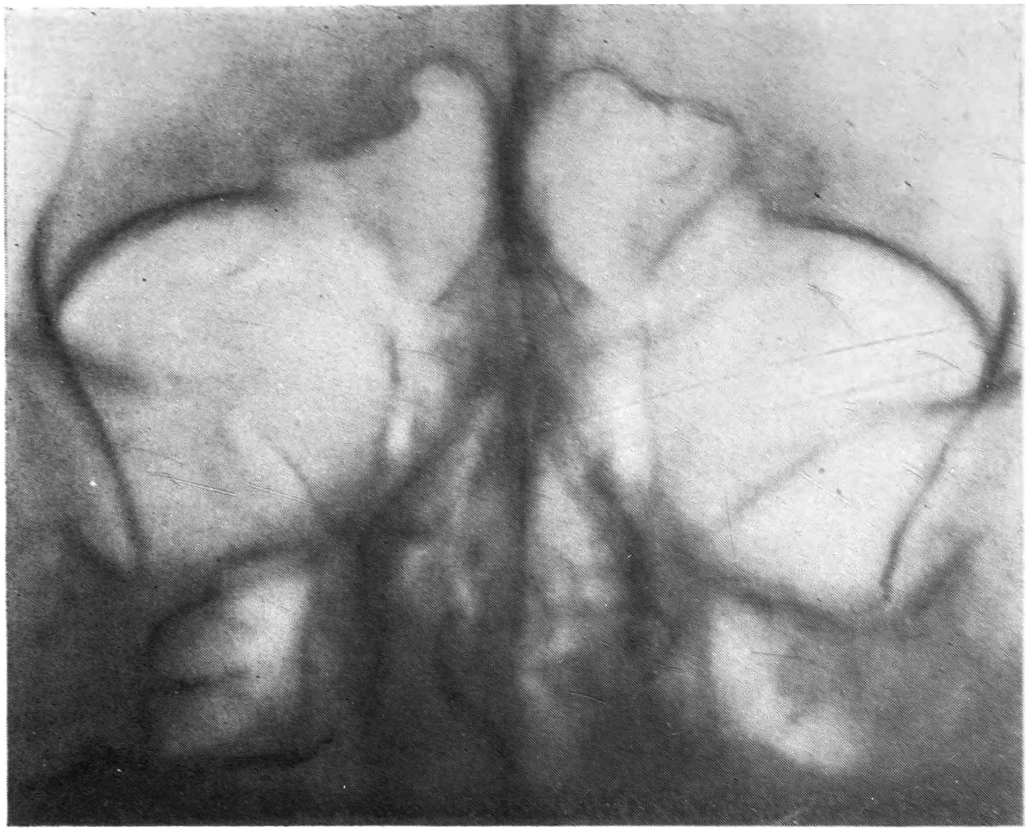


Fig. 38. A small osteoma arising from the supero-external portion of the right frontal sinus

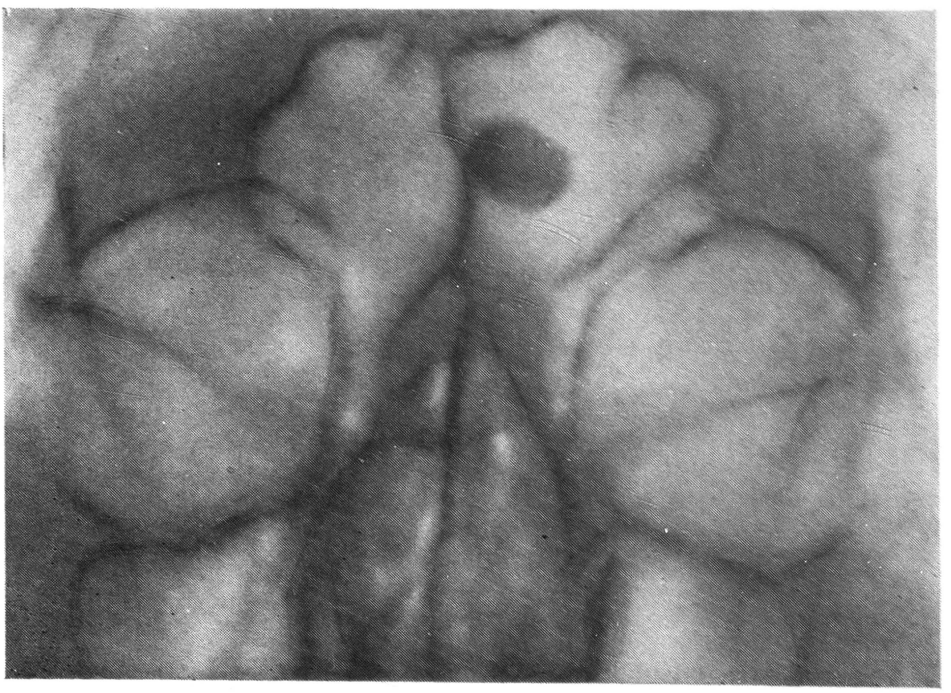


Fig. 39. A small osteoma of the left frontal sinus arising from the inter-frontal septum

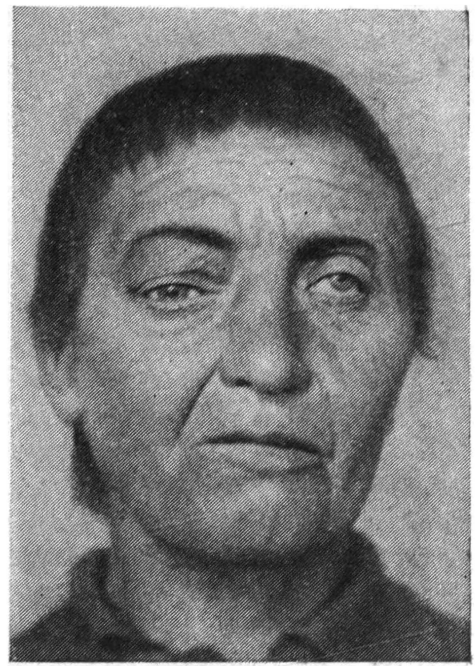


Fig. 31. Exophthalmos; narrowing of the right palpebral fissure; diplopia; bilateral dacryocystitis. A defect at the inner orbital angle is felt on palpation of the roof of the right orbit. Diagnosis: mucocele of the right-side frontal sinus

shot" and "squint", with added diplopia and unsteady gait. Protrusion of right eyeball with excessive lacrimation followed.

Right eyeball displaced down- and outwards (Fig. 31) and its upward movements limited. Swelling in upper eyelid, mostly extending inwards, eyelid itself being pushed forwards and downwards. Bony wall of orbit very tender on pressure with finger, particularly in inner portion of orbit. Bone defect felt at supero-internal wall of orbit with "bony crown" outgrowth along its margins. Through this defect the tumour could be pushed towards the frontal cavity. Palpebral fissure somewhat narrowed. Inferior lacrimal punctum lay apart from eyeball. Lacrimal lake brimming. No discharge from lacrimal puncta on pressure applied to lacrimal sac. Cornea transparent and lustrous, anterior chamber shallow, iris pattern intact, pupil round, refractive media transparent, retina edematous, optic disk borders blurred, veins dilated and arteries markedly stenosed. Acuity of vision with correction 1.0.

Nose with hypertrophy of inferior turbinate. Otherwise nose, ear and throat normal.

X-ray examination revealed distention of the right frontal sinus which was almost quadrangular. Its floor was hardly discernible and depressed into the orbit; the interfrontal septum could not be differentiated; the upper portion of the internal orbital wall was destroyed; the ethmoid labyrinth and the antrum of Highmore on the same side were slightly shadowed (Fig. 27).

A large defect in the orbital roof was discovered at operation; the floor of the frontal sinus was absent, and the internal wall of the orbit completely destroyed. Apart from the cyst containing a viscid colloid mass, polyps were

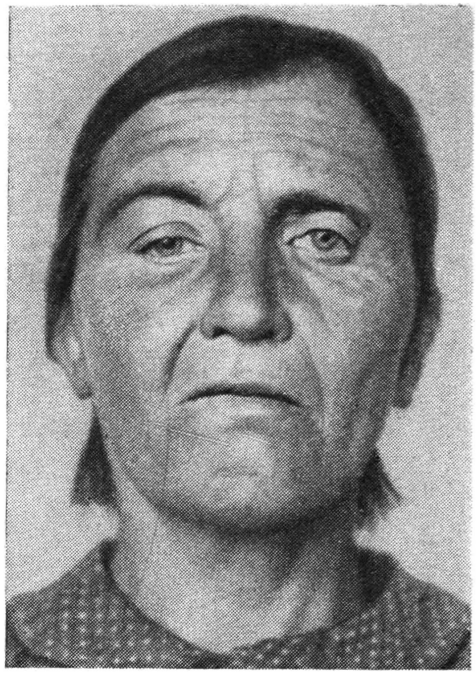


Fig. 32. The same case as in Figs. 31 and 27. The patient after an operation. The diagnosis of mucocele has been confirmed

detected in the frontal sinus and ethmoid labyrinth. Following the operation diplopia disappeared. Continual lacrimation on the operated side ceased, but persisted in the other eye. The eyeball went back into place and regained mobility (Fig. 32).

The ethmoid labyrinth is the second most frequent site of mucocele, which in most cases invades it from the frontal sinus.

The cyst of the ethmoid labyrinth may grow both outwards and into the nasal cavity. In the former case, the protrusion will be found at the inner palpebral angle owing to the outward displacement of the internal labyrinthine wall; the latter case, however, is characterised by bleb-like, or bullous, swellings in the anterior portion of the middle nasal turbinate. The mucocele of the ethmoid labyrinth rarely extends towards the nose.

The only characteristic symptom of this disease is exophthalmos, which, however, fails to develop with the same regularity as in the cystoid distention of the frontal sinus. The mobility of the eyeball is nearly always unaffected and cases of optic nerve lesions are exceedingly rare. X-rays show one large cavity, since the partitions between individual labyrinthine cells are broken down.

Below is a case report of a cystoid distention of the ethmoid labyrinth.

Case report 14. Patient R., female, aged 15, hospitalised for suspected giant-cell orbital tumour.

Persistent lacrimation from right eye since early childhood. Right eyeball protrusion since the age of 10. On clinical examination right eyeball found to protrude forward 5 mm and somewhat outwards; mobility not limited. Under upper eyelid and above internal ligament an elastic round formation the size of a common kidney bean, painless on pressure. No discharge on pressure applied to lacrimal sac. Ocular conjunctiva unchanged, cornea lustrous and transparent, anterior chamber of normal depth. Other refractive media transparent. Optic disc without pathological changes. Acuity of vision 1.0. Left eye normal. No changes in nose.

An X-ray examination established a considerable atrophy of the internal wall of the right orbit and its displacement into the orbital cavity. The ethmoid cells coalesced into one wide cavity. A walnut-sized cyst in a very thin-walled sac was projected in the area of the labyrinth, the inner third of the orbit and the nasal cavity. The frontal and maxillary sinuses on the right side were shadowed (Fig. 28). A large cyst invading the entire ethmoid labyrinth and sphenoid sinus was discovered at operation; the cyst contents were a thick, viscid and whitish mass. A week after the removal of stitches the eyeball had almost completely returned to its proper place.

The sphenoid sinus. Most authors assert that isolated cysts of the sphenoid sinus are encountered very rarely. Indeed, in daily practice the mucocele of the sphenoid sinus is encountered together with analogous processes in the other paranasal sinuses (usually in the ethmoid labyrinth, less frequently in the frontal sinus).

The information available in the literature confirms this opinion. Thus, in 1957 Neffson published his own observation of a cystoid distension of the sphenoid sinus, where he referred to only two cases of isolated mucocele of the sphenoid sinus previously described in the literature. Mayer, however, in his report to the 9th Congress of Austrian Otorhinolaryngologists on the use of X-rays for the diagnosis and therapy of E. N. T. diseases (1954) asserted that the common view of the sphenoid sinus mucocele as an exceedingly rare occurrence was erroneous. Cystoid distentions of the sphenoid sinus were simply difficult to identify because in his opinion their clinical symptoms were unmarked and X-rays pictures were interpreted as tumours of the base of the skull on account of their likeness to the disease in question.

An X-ray picture suggesting a benign process in the region of the Turkish saddle may with equal reason be ascribed to a mucocele in the sphenoid sinus; in Mayer's view, a benign process is a condition where bony tissue is delimited and displaced, the saddle dorsum backwards and the planum sphenoidale upwards, calcareous deposits being in certain cases identifiable in the periosteum. The destructive process in the region of the Turkish saddle, however, is characterised by destruction of the latter with retention of the upper dorsal portion and absence of a substantial expansion of the entrance to the Turkish saddle region.

In Neffson's observation an X-ray examination of the paranasal sinuses revealed destruction of the sphenoid sinus. The clinical picture consisted of both purely ophthalmic symptoms (diplopia, large loss of vision) and rhinological signs (nasal polyps).

According to the literature available on the subject, the sphenoid sinus mucocele is characterised by exophthalmos, unilateral or bilateral lesion of the optic nerve, retrobulbar neuritis, bilateral optic nerve atrophy, and paralysis of the oculomotor nerves. These changes are perfectly logical in view of the anatomical relationships between the sphenoid sinus, orbit and optic nerve; changes in the latter are usually attributed to compression of the nerve by a wall of the distended sphenoid sinus.

Rhinoscopical examination of a mucocele in the sphenoid sinus may reveal protrusion of its anterior or posterior wall, and the same symptoms may be established by probing as in palpation of a mucocele in the fronto-ethmoidal region, i.e., parchment-crackling and elastic resistance.

The maxillary sinus. The probability of a mucocele developing in the maxillary sinus was long refuted by prominent specialists in the U.S.S.R. and elsewhere, and the cases described in the literature were considered by most authors to be odontogenous cysts.

In 1912, V. I. Voyachek demonstrated a case of an indubitable mucocele of the maxillary sinus, and in 1925, P. N. Kartashev published a paper describing four equally unquestionable cases confirmed by histological studies. A mucocele in the maxillary sinus was also observed by N. D. Khodyakov and A. G. Likhachev. The latter described a simultaneous cystoid distention of the maxillary and fronto-ethmoidal sinuses.

The studies made by Y. S. Temkin, who discovered large serous cysts which, rather than break, distended through the principal or accessory orifices of the maxillary sinus, prove that the latter can also become the source of a mucocele.

In cases of an isolated affection of the maxillary sinus, the clinical symptoms of a mucocele are protrusion of the eyeball, its displacement upwards and outwards, and limitation of its downward movement. There is parchment-crackling and elasticity felt on finger palpation, which indicates the atrophy of the frontal wall of the sinus.

Diagnosis. The concise statement by M. I. Averbach in the epigraph to the present Chapter gives an exhaustive definition of the basic clinical symptoms facilitating the diagnosis of mucocele.

1. The first symptom to suggest a mucocele is exophthalmos; anamnesis invariably reveals that the process has been developing slowly, over several years.

2. Exophthalmos, which is present in more than half of the cases, is nearly always attended with displacement of the eyeball,

usually downwards, as well as down and outwards. Limitation of eyeball mobility is a less frequent sign.

3. A swelling, often fluctuating, can nearly always be discovered at the supero-internal or internal orbital angle. An elastic obstacle of bony consistency is felt on finger palpation with crepitation of parchment-crackling elicited by pressure.

4. No inflammatory signs are, as a rule, found in the soft orbital tissues and the palpebral skin.

5. In certain cases the cyst can be pushed towards the sinus through a bone defect in the orbital wall, and a bony outgrowth may be felt around its edges.

Rhinological examination rarely leads to the detection of a bullous intumescence in the anterior portion of the middle nasal turbinate to suggest an ethmoidal mucocele growing into the nasal cavity. In the majority of cases, a mucocele either gives no symptoms or produces uncharacteristic hypertrophy of the middle nasal turbinate, or its polypous degeneration.

Though the above-mentioned symptoms are very important for diagnosis, the decisive factor, particularly in the case of unmarked clinical signs, is the X-rays which in most cases permit to establish the presence of a mucocele and to determine its size as well as the character of the changes in the bony wall separating the sinus from the orbit.

The X-ray examination should be undertaken in two perpendicular projections: the sagittal and the lateral. We employ the anterior and semiaxial projections which supplement each other and provide an adequate picture of all the paranasal sinuses save the sphenoid. The sagittal pictures should be supplemented with a lateral one taken to determine the depth of the frontal sinus, the antero-posterior extension of the sphenoid sinus and its height.

For a better representation of the sphenoid sinus, a picture is taken in the axial projection to ascertain the state of the posterior ethmoid cells.

Sometimes a skull picture in an oblique projection is required to determine the condition of the ethmoid cells and the sphenoid sinus and their relationships with the facial nerve canal.

A marked frontal sinus mucocele is not particularly difficult to diagnose by means of X-rays, which commonly reveal a distention of the sinus and protrusion of its floor into the orbital cavity. The causative factors are : (1) increased pressure of the cyst contents on the sinus floor and (2) thinness of the orbital cavity roof. In addition to ectasia of the frontal sinus, the X-rays permit observation of a decrease in the orbital cavity size, which is particularly evident on comparison with that of the normal cavity.

It should be noted that the initial forms of cystoid distention of the paranasal sinuses are not always identifiable even by means of X-rays.

There is sometimes a discrepancy between X-ray and operational data. For instance, an X-ray record may indicate atrophy of the orbital roof or its very slight differentiation, whereas an extensive destruction of the bony wall may be discovered at operation. Upon a careful examination of X-ray films made before and after surgical interference we drew the conclusion that the thickened wall of the cyst capsule seen as a thin and hardly visible line (Fig. 33) is sometimes mistaken for the sinus floor.

If the cyst capsule is very thin and the orbital roof has been completely destroyed the frontal sinus in the film will appear fully merged into the orbital cavity (see Fig. 27).

Both sinuses also merge in cases of destruction of the interfrontal septum, an irregular transparency being frequently noted in the picture, since the air is partly retained on the healthy side.

Pathological changes in the anterior and posterior walls of the frontal sinus are best determined in a lateral picture, yet it should be borne in mind that such a picture reveals only considerable defects in the bony wall. Owing to the divergence of the X-rays small defects produce no image on the film and can be only found at operation.

Finally, one should take note of the upper and outer borders of the sinus, which normally appear as an irregular wavy line. Under a constant pressure from the cyst contents the sinus contours in these portions begin to flatten out and take the form of a straight or convex line. In mucocele of the ethmoid labyrinth the intercellular partitions are the first to suffer resorption and form a homogeneously shadowed cavity.

The pliable, elastic papyraceous lamina of the ethmoid bone is the first to yeild to the pressure of the cyst contents and bulge towards the orbit. In such cases the inner wall of the orbit is shown by the X-ray as a thin convex line which sometimes reaches far into the orbital cavity. Just as in the case of a frontal sinus mucocele, the destruction of the papyraceous lamina may reveal the contours of the indurated cyst capsule, which may be mistaken for an atrophied internal wall of the orbit. The differential diagnosis between mucocele of the ethmoid labyrinth and a dilated lacrimal sac can in certain cases be verified only after the lacrimal sac has been filled with a contrast mass (Fig. 34).

The X-ray diagnosis of mucocele of the sphenoid sinus is based on the same signs that have been indicated in the description of mucocele of the frontal sinus and ethmoid labyrinth, of which the basic symptom is distention of the sinus. Its changes can best be discovered in an axial picture. Since the sphenoid sinus mucocele sometimes causes affections of the optic nerve, the latter's canal should by all means be examined by X-rays.

We have not observed a single case of a maxillary sinus mucocele, where the basic symptom is distention of the sinus and atrophy of its

walls. The differential diagnosis has to be applied to a cyst of odontogenous origin. For small cysts which only partially fill the sinus the diagnosis is easy, whereas complete obstruction of the sinus sometimes frustrates all efforts to identify the cause.

DIFFERENTIAL DIAGNOSIS

Among the diseases which are similar to mucocele, in regard to a number of clinical signs, hernia of the brain and dermoid cyst deserve to be mentioned first.

Congenital naso-frontal, naso-ethmoidal and naso-orbital cysts of the brain. In marked cases the signs of these diseases are so typical as to cause no doubt in diagnosis. In unmarked cases, however, they have much in common with a mucocele in appearance, location and consistency. Diagnosis is facilitated by the fact that mucocele is commonly confined to adults and to children of 10 to 11, i.e., of an age when the paranasal sinuses, which are the site of mucocele, have more or less developed. Hernias of the brain, being congenital, are commonly encountered in childhood when the paranasal sinuses, the frontal sinus in particular, are still underdeveloped.

Taking into account a number of signs typical of hernias and nontypical of mucocele, the diagnosis can be made without particular difficulties. Among the symptoms characteristic of naso-orbital hernias of the brain one may list the absence of tension in the tumour, transmission of brain pulsations, changes of the tumour size in respiration, its tension on strain or pressure, symptoms of brain compression (pulse deceleration, convulsions, coma, etc.), i.e., all the signs indicating a relation of the tumour to the brain.

Considerable difficulties are involved in identifying a mucocele which has destroyed not only the orbital but also the posterior, that is, cerebral wall of the frontal sinus, with the result that the brain pulsations are transmitted to the tumour.

In such cases the diagnosis is facilitated by X-rays since apart from the basic X-ray symptoms of mucocele which we have already discussed there are signs characteristic of brain hernias in this region. In cases of brain hernia it is possible to discover a defect of round or oval shape with clear-cut and sometimes indurated margins at the junction of the frontal and the ethmoid or nasal bones. A lateral picture shows a characteristic overhanging protrusion of the bone margin (Fig. 35).

The paper published in 1955 by Wild, Sichel and Klotz described two cases of mucocele of the ethmoid labyrinth, one of which gave clinical symptoms suggestive of a meningocele. In this case the diagnosis had to be verified by tomography.

The dermoid cyst is a disease quite frequently encountered by ophthalmologists, particularly by ophthalmic surgeons.

Dermoid cysts are classed among mixed tumours which develop from several different tissues, and are not tumours (blastomata) in the true sense of the word. They should rather be regarded as malformations since their origin is associated with the detachment of separate portions of the ectoderm and their submergence in the underlying tissue. The most favourite sites of dermoids are the head at the great and small fontanels, and the root of the nose, at the junction of the maxillary process and the frontal bone.

A dermoid is a single- or multi-chamber cystoid tumour containing a viscid pulpy mass with inclusions of hairs, epidermal scales, etc. If its walls contain a large number of sebaceous glands its contents will look like thick lard; but should sudoriferous glands be prevalent, the dermoid will resemble a cystoid serous cyst. The progress of the dermoid cyst is slow.

The dermoid cyst develops in the anterior portion of the orbit, at the inner, or—less commonly—at the outer margin, i.e., periorbitally, and is always connected with the periosteum. It is located in a bony depression with flat or knobby margins, which is the result of hampered bone growth rather than atrophy under the pressure of the dermoid. The depression may be so deep as to leave almost no room for bone, so that the dermoid comes into direct contact with the dura mater and transmits brain pulsations.

All this has to be taken into account in the case of cyst at the root of the nose, where it can be mistaken for a brain hernia.

In cases of a dermoid cyst being located at the inner angle of the orbit or extending therefrom to the orbital cavity, it should be differentiated from a mucocele.

A thick-walled tumour always indicates a dermoid, whereas a mucocele has a thin elastic sac; moreover, a dermoid cyst is never felt to fluctuate.

The basic method of diagnosis is X-ray examination.

Given below is a case report of mucocele of the ethmoid labyrinth mistaken for a dermoid cyst as a result of diagnosis on the strength of the outward signs alone, without an X-ray examination.

Case report 15. Patient K., male, aged 37, under a year-long ophthalmological observation for swelling at supero-internal angle of right orbit and excessive lacrimation. No disease of lacrimal passages found; swelling diagnosed as dermoid cyst, patient admitted to hospital.

Right eye: skin above internal palpebral ligament elevated; heavy, elastic and almost immobile tumour the size of a nut and unconnected with skin felt on palpation; eye itself unchanged. Polyps and pus found in both nasal cavities. Pus discharge from right nasal cavity noticeably increased on pressure applied to orbit, while tumour at inner orbital angle diminished. Its size also changed spontaneously, i.e., without application of pressure.

X-rays examination showed that the supero-internal margin of the right orbit was dimly outlined and somewhat pushed downwards; the right-side

Fig. 36. The same case as in Fig. 34. Photo taken before the operation

Fig. 37. The same case as in Figs. 34 and 36. Photo taken after the operation

ethmoid labyrinth looked as fairly large structureless cavity; the papyraceous lamina was pushed to the orbit, the pneumatisation of the maxillary and frontal sinuses was decreased; and the lacrimal passages were patent (see Fig. 34).

Presumption of a dermoid cyst was discarded for the following reasons: dermoid cysts do not fluctuate in size, as is the case under study, nor are they connected with the nose and its accessory sinuses; therefore no explanation could be offered for the pus being expressed by pressure on the cyst and driven into the nasal cavity. At the same time X-ray examination of the paranasal sinuses revealed considerable changes characteristic of a mucocele. The operation which followed confirmed the clinico-roentgenological diagnosis of mucocele, or rather a pyocele of the ethmoid labyrinth.

It was discovered at operation that the inner wall of the left orbit had been almost completely destroyed, and a large bone defect existed at its supero-internal angle in the ethmoid labyrinth region a large cystoid sac was found, which was filled with viscid liquid and pus and extended far upwards to the frontal sinus, and downwards, to the nasal cavity. The frontal sinus contained a small quantity of viscid slime and a large quantity of pus. The posterior wall of the frontal sinus had been destroyed, and the exposed dura mater was covered with granulations. Figs. 36 and 37 show photos of the patient before and after the operation.

This case is interesting not only in respect of diagnosis, but also because pyocele is rarely encountered in the case of an incom-

plete valvular obstruction of the natural orifice. Such an obstruction is characterised by periodical spontaneous evacuation and drainage of the cyst contents into the nasal cavity, especially on pressure applied to the tumour. Another noteworthy circumstance is that the relatively unmarked orbital symptoms concealed extensive destruction of the bony walls of the sinus and exposure of the dura mater.

Ectasia of the lacrimal sac is sometimes mistaken for a mucocele. The following facts are helpful to a correct diagnosis: a mucocele arising from the ethmoid labyrinth and especially that from the frontal sinus is always located above the internal ligament, whereas an ectatic lacrimal sac is found below it. If pus can be expressed from the lacrimal punctum by pressure on the tumour and the latter decreases in size, one can be sure of a lacrimal sac affection and thus rule out a mucocele.

Osteomata, like mucocele, most frequently extend towards the orbit, where they cause the same processes of atrophy and resorption of bony tissue. The difference between the mucocele and the osteoma lies primarily in the fact that in the latter a formation with a rough surface is revealed by palpation of the corresponding parts of the roof and internal walls as well as the supero-internal angle of the orbit instead of a resilient, elastic or fluctuating tumour with a smooth surface, and gradually extending to the orbit. This is sufficient to rule out a mucocele and to suspect an osteoma. The problem is usually solved by X-rays. It should be remembered that the course of osteoma may sometimes be complicated by a concurrent empyema.

Sinusitis. Difficulties in differentiating a mucocele from common suppurative processes in the paranasal sinuses are likely to arise while symptoms are absent. Once the disease has taken a violent course its diagnosis is easier. Mucocele, running an acute course, is observed only when the primary process is joined by a secondary infection. Particularly difficult for diagnosis are cases with residual symptoms following recovery from sinusitis. The tenderness felt on palpation and sometimes persisting after the passage of the acute stage of periostitis and subperiosteal abscesses, as well as history of the case (development of the disease after coryza, influenza, etc.) are always evidence against a mucocele. A chronic sinusitis producing perforation of the bony wall and giving rise to a subperiosteal process, such as a congestive abscess, sometimes causes a very slight distention of the sinus.

In the majority of such cases the diagnosis also rests on X-rays.

Below is reported a case where even a preoperative X-ray examination failed to reveal the genuine cause of the disease and the diagnosis wavered between chronic sinusitis and mucocele.

Case report 16. Patient K., female, aged 60, hospitalised for right-side frontal sinus empyema suspected as mucocele. Five months previously fore-

head bruised against a table, continuous pain at side of contusion ever since. Two months later edema in right upper eyelid and eight days before admittance onset of sanguine-purulent discharge from nose.

Right eye: eyeball position normal, slight palpebral edema and tenderness in superciliary region and at inner angle of upper orbital margin. Moderate resistance felt on palpation of middle third of eyelid, immediately under orbital margin. Refractive media transparent, ocular fundus without pathological changes. Left eye normal. No pathological changes in ear, nose and throat save for hypertrophy of inferior nasal turbinates.

X-rays showed that the right frontal sinus was larger than the left; its outline was clear except in the supero-internal portion and the interfrontal septum; the internal two thirds of its borders with the orbit were blurred; the sinus was irregularly transparent and its infero-internal portion was clouded; the left frontal sinus was also irregularly shadowed, particularly intensely in the inner portion adjacent to the right frontal sinus; the cells of the ethmoid labyrinth were of adequate transparency, while the left maxillary sinus was slightly shadowed.

The absence of orbital symptoms characteristic of a mucocele spoke in favour of an empyema, whereas the slight resistance felt on palpation in the upper eyelid can also be observed in sinusitis. The only facts in favour of a mucocele were the injury mentioned in the case history and the right frontal sinus being larger than the left, which we concluded to be an individual feature; an empyema was therefore presumed.

The subsequent operation proved that we had been mistaken, since a thick, viscid slime began to discharge on pressure as soon as the skin incision was made. Apart from a defect in the orbital roof, atrophy and destruction of the internal wall, complete obliteration of the naso-frontal canal was discovered.

Psammoma is a disease which is likely to be mistaken for a mucocele, as is pointed out by E. F. Levkoyeva and A. G. Likhachev.

Discussing its clinical picture it should be remembered that this disease is extremely rare (see Chapter V).

TREATMENT

Surgery is the only remedy for mucocele. The common surgical procedure is an external excision, whereas advocates of an endonasal surgical approach are few, as are those who employ both methods.

Whether the sinusal mucosa should be fully removed, or it is enough to remove its hypertrophied and necrotic portions is still a matter of controversy. Killian, Hajek and others maintain that it is necessary to remove the entire sinusal mucosa, whereas the majority of authors (S. S. Golovin, who was the first to operate on the cystoid distentions of the paranasal sinuses, A. G. Likhachev, with his extensive clinical experience, and others), consider the

Fig. 40. Exophthalmos; displacement of the right eyeball out- and downwards. Protrusion of the supero-internal boundary of the orbit. Diagnosis: mucocele of the right frontal sinus

removal of the entire sinusal mucosa superfluous and even harmful. Thus S. S. Golovin writes: "It is difficult to scrape away the entire sinusal mucosa, while its partial removal may lead to contraction of the walls and formation of a closed cavity where the cyst is likely to recur since the sinus will become overgrown with an epithelium favouring its recurrence." In a monograph on mucocele published in 1948 A. G. Likhachev expresses a similar view: "...there is no need for a careful removal of the entire sinusal mucosa in order completely to empty the sinus, as was frequently practised for empyema of the frontal sinus."

Proceeding from our own observations we recommend this particular procedure (abstention from removal of the mucosa) since we have never encountered a relapse following its use.

Neither is there unanimity among surgeons concerning the formation of a communication between the nose and the frontal sinus. Most Russian specialists, S. S. Golovin included, provide it by implantation.

So far as the choice of an external operation is concerned, experience leads us to agree with A. G. Likhachev's view that no standard procedure can be recommended for all types of mucocele. We have always started an operation with the standard arched incision and opened the frontal sinus through the orbit, i.e., by the Jansen and Ritter method, and then made additional incisions, depending on local topography, i.e., the size of the sinus, the presence of crypts and partitions within it, in order to make the sinus accessible to curettage of its pathological contents. We have never had occasion to resort to fronto-orbital opening of the frontal sinus after Riedel.

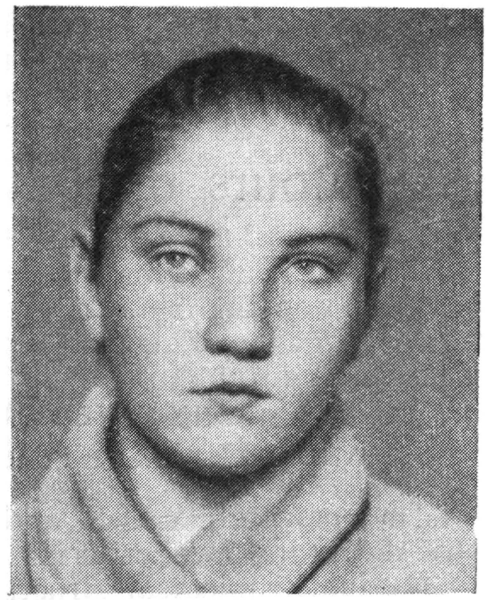


Fig. 41. The same case as in Fig. 40. The patient after on operation which confirmed the tentative diagnosis of mucocele

The outcome of surgical treatment of mucocele is quite satisfactory as regards pathological symptoms and the cosmetic aspect. The eyeball usually returns to normal, diplopia and dacryocystitis pass, and the eyeball recovers its mobility.

The following report demonstrates the results of such surgical interference.

Case report 17. Patient S., female, aged 16. Complains of gradual right eye protrusion in progress for 3 years. Right eyeball markedly protruding forwards and displaced out- and downwards (Fig. 40). Prominence in supero-internal orbital margin. Eyeball mobility preserved, optic functions undisturbed, refractive media and ocular fundus normal. Left eye normal. On rhinoscopical examination hypertrophy of right-side middle nasal turbinate. Otherwise ear, nose and throat normal.

X-rays revealed the destruction of the entire floor and partially the internal wall of the right orbit; the ethmoid sinuses and the right maxillary sinus were shadowed; the transparency of the frontal sinuses was satisfactory, though the left sinus was slightly dimmed.

The operation confirmed the diagnosis of a mucocele. A viscid slime was discovered in the right as well as in the left frontal sinus and the interfrontal septum was found destroyed. The cyst extended to the right ethmoid labyrinth, which represented a large round cavity partially invading the orbit. The postoperative course was uneventful with healing by first intention. Within seven days the eyeball had returned to its normal place (Fig. 41).

The only knoun complication following an operation on the fronto-ethmoid region is postoperative diplopia, which usually passes within 7 to 10 days of the operation and very seldom persists for a longer time.

V

Tumours of the Orbito-Sinual Region

BENIGN NEWGROWTHS OF THE NOSE AND PARANASAL SINUSES EXTENDING TO THE ORBIT

Tumours are classified as benign or malignant on the basis of the following two criteria:

(1) the histological structure of the tumour as determined by a morphological analysis, and the relation of the newgrowth to the adjacent organs and tissues;

(2) clinical follow-up data on the rate of growth, predisposition to relapse following removal of the tumour, liability to metastasis, presence or absence of cachexia, etc.

As a rule, there is parallelism between the histological picture and the clinical course. In certain cases, however, such correspondence between the morphological data and the course of the process is non-existent. To put it differently, in the presence of a microscopical picture typical of a malignant newgrowth, the process takes a benign course, or vice versa. Take, for example, the basalioma, which produces no metastases and has an insignificant general influence on the body. And, conversely, tumours with a benign morphological structure, such as the chondroma and some forms of the adenoma, may take a malignant course, producing metastases, causing cachexia, etc.

The following circumstances should not be overlooked: (1) tumours with an identical morphological structure, for instance, adenomata, may take a different course; (2) it is not always possible to draw a dividing line between benign and malignant tumours; (3) in certain cases the picture is that of one form of newgrowth transforming into another; this phenomenon may be observed when traces of immature tissue are found in a mature benign tumour, as in a chondroma. These facts serve to indicate that the accepted classification of tumours into benign and malignant is merely conventional.

Benign tumours, which comprise the mature forms, have the following characteristics.

1. *A focal, expansive growth* which essentially consists in that the tumour only pushes apart and presses on the surrounding

organs and tissues while remaining markedly circumscribed among the adjacent tissues without penetrating them, as is observed in infiltrative growth. This kind of tumour development and its relationship to the adjacent tissues and organs permits its complete excision with no risk of relapse.

2. *A slow progress of the newgrowth* which is observed in mature tumours with a well-developed stroma. Since benign tumours do not infiltrate blood and lymphatic vessels, neither metastases, nor cachexia are associated with the decay of the malignant newgrowth and absorption of the toxins produced by incomplete disintegration of proteins with a resulting general intoxication and anemia.

Not all tumours of the nose and paranasal sinuses play an equal role in the pathogenesis of orbital complications.

The clinical symptoms of some benign newgrowths in the paranasal sinuses and their relationships with orbital diseases are so invariable that the patient usually first applies to an ophthalmologist. Among such benign tumours is the osteoma. Other benign newgrowths, whose incidence is comparatively low, naturally play a lesser role in the clinical cases of orbital affections than does the osteoma; these comprise fibroma, chondroma, adenoma and epidermoid. The other benign newgrowths of the nose and paranasal sinuses, such as lipoma, myxoma, fibromyxoma, neurinoma and neuroma, psammoma and cementoma, contribute still less to the pathogenesis of orbital affections.

OSTEOMA

The most frequent benign tumour of the paranasal sinuses is the osteoma.

This tumour is likely to arise both in bones and bone cavities; the cranial bones, particularly the frontal and the temporal, are predisposed to the formation of outgrowths and tubercles, exostoses, both on the external surface of the bone (osteoma corticalis externa) and on the internal surfaces of bony cavities, as in the paranasal sinuses (osteoma corticalis interna).

Exostoses may subsequently develop into large osteomata. We shall here discuss sinusal osteomata arising in the paranasal sinuses.

Growing towards the orbit these sinusal osteomata produce a number of symptoms in the eyes, for which reason the patients commonly first apply to an ophthalmologist.

Pathogenesis. Two of the theories offered to explain the origin of the paranasal sinus osteoma deserve special mention: the theory of the development of an osteoma from the remnants of embryonal cartilage, and the theory of its origin in rudimentary connective tissue, i.e., the future periosteum.

The first theory was suggested by the pathoanatomist Arnold in 1873. According to his view, the fact that the ethmoid labyrinth

develops from the remnants of embryonic cartilage proves that labyrinthine osteomata have the same origin. The following arguments were adduced to confirm this view: (1) In addition to the connective tissue the cartilaginous elements of the anterior ethmoid cells also take part in the formation of frontal sinuses; (2) the contact of two heterogeneous tissues—the connective tissue from the frontal bone and the embryonic cartilage from the ethmoid labyrinth—may contribute to the development of newgrowths from the embryonic rudiments.

In addition to purely embryological data, Arnold's theory is corroborated by clinical observations, the greatest significance being attributed to malformations, such as exostoses on the ungual phalanx of the thumb, underdevelopment of the uterus, accretion of the toes, fistulas of the auricles caused by atresia of the branchial clefts and a number of other related factors.

Besides the clinical observations which confirm the embryonal cartilage theory of the labyrinthine osteoma, there exist, however, a number of facts which contradict this theory. Among them, for example, are observations of the frontal sinus osteoma developing from the flat cranial bones, which are genetically unconnected with cartilage, as well as F. I. Dobromylsky's and M. M. Baltin's observations on the so-called rudimentary osteomata commonly discovered in the upper portion of the frontal sinus and on the interfrontal septum, i.e., in places where cartilaginous tissue is absent (Figs. 38 and 39).

The second, periosteal, theory was evolved in 1931 by A. G. Fetisov from a comprehensive clinical and pathoanatomical study of comparatively extensive volume of material. His basic conclusions are the following:

(1) osteomata usually develop as a result of metaplasia of fibrous tissue into bony tissue in the central portions of the bone, where spongy tissue is to be found; in other words, bone formation occurs from connective tissue, as in embryonal development;

(2) the development of an osteoma from periosteal osteoblasts is observed less frequently;

(3) besides the bone formation process, resolution of bone as a result of osteoclast activity is also observed in osteoma.

This theory was supported in 1938 by A. P. Odoyevsky and A. I. Vorotilkin.

An important argument in favour of the latter theory is the existence of a certain similarity between nasopharyngeal osteomata and fibromata, whose connective-tissue origin has been proved beyond doubt. This similarity consists in that fibromata are often found to contain bony tissue with well-developed osteoblasts, whereas osteomata contain substantial bundles of connective tissue. In one of A. G. Fetisov's observations osteoma largely resembled a fibroma in structure. The existence of tumours of

Fig. 42. A dense (eburneum) osteoma

an intermediate type, such as the osteofibroma and the osteochondroma, also supports the view that the origin and development of the osteoma and the fibroma of the nasopharynx are largely similar.

Pathological anatomy. Osteomata are classified as follows: (1) dense (eburneum) osteomata (Fig. 42); (2) osteomata with a spongy structure; and (3) medullary osteomata which are encountered rarely. In most cases we find osteomata of a mixed type, combining dense and spongy tissue. Such osteomata consist of the following layers: (1) a mucous membrane covering the tumour; (2) a periosteum; (3) a dense bone; and (4) spongy bony tissue.

The mucous membrane covering the osteoma consists of a ciliated columnar epithelium which is very thick, particularly in bone depressions; in prominent places, however, it is thinned out and even atrophic.

Under the mucous membrane there is a loose layer of connective tissue, which is a periosteum. On the internal surface of the periosteum adhering to the osteoma sac are often found osteoblasts, which lend the periosteum osteogenic properties (A. G. Fetisov). In certain sectors, the bundles of connective tissue along with a large number of vessels penetrate and fill the marrow spaces of the osteoma, where subsequently calcareous deposits form, and connective tissue cells (fibroblasts) turn into bone cells.

According to A. G. Fetisov, bone formation thus occurs in two ways: (1) as a result of the activity of periosteal osteoblasts, and (2) by metaplasia of the fibrous tissue into bony tissue in the central portions of the tumour. Bone formation after the type of embryonal development from connective tissue prevails over the osteoblastic processes.

The dense part of the osteoma resembles the bone diaphysis but as a result of eburnation it contains few haversian canals, and these are in disorder. The same is true of Havers' lamellae which are not arranged concentrically around the canals but extend in various directions, being tightly fitted one upon another with few bone corpuscles in-between.

The spongy layer of the osteoma is characterised by the prevalence of marrow spaces over bony tissue. It is completely devoid of haversian canals, while the bony canals run in parallel. Between them lies soft tissue rich in fat and vessels, as well as connective tissue possessing osteogenic properties. The bone cross-bars of the spongy part of the osteoma are sometimes found to contain Sharpey's fibres; the cross-bars themselves are stratified.

Clinical symptoms. Clinically, the disease becomes apparent when the tumour has penetrated into the orbit and ophthalmic symptoms come to the fore.

Below is described an observation of this particular case when a paranasal sinus osteoma was not identified at the time, and the diagnosis of orbital osteoma was made only five years later on the basis of a number of ophthalmic symptoms.

Case report 18. Patient Z., male, aged 30. Diagnosis: orbital osteoma. According to ambulant record of Alekseyevskaya Infirmary in Moscow eyeball displacement noted as early as June, 1918. On admittance on February 17, 1923, complains of certain loss of vision and facial deformity due to downward eyeball displacement. Disease in progress for five years. On examination asymmetry in eyeball position on both sides: right-side exophthalmos and downward displacement of affected eye (Fig. 43). Upward movements of eyeball limited. Insignificant ptosis. On palpation of supraorbital margin tumour of dense consistency, extending 3 to 4 cm over the middle part of supraorbital margin save for small area at outer and inner angle of the eye. Tumour transgressing orbital margin without clear borderline; groove between margin and newgrowth felt only on inner side. Farther on tumour felt under orbital roof first overhanging eyeball, then invading orbit, palpable all over. A slight elevation of the upper eyelid immediately revealed a lacrimal gland displaced by the tumour downwards and nearly reaching the eyelid edge. Ocular conjunctiva unchanged, cornea transparent, anterior chamber deep. Iris colour and pattern unchanged. Pupil of regular form, with quick response to light. Refractive media transparent. Ocular fundus without pathological changes. Acuity of vision 0.3. Intraocular tension normal.

X-rays showed that the bony outgrowth within the orbit was closely connected with an analogous formation in the frontal sinus. A profile picture showed that the greater mass of the tumour was located not above the eyeball but behind it, in the depth of the orbit.

The patient was subjected to an operation. The excised tumour proved to be a compact mass weighing 18 g and covered by a periosteum. It had developed from the frontal sinus and its place of attachment was the border

Fig. 43. Osteoma of the right frontal sinus. Right-side exophthalmos and downward displacement of the eyeball. Upward movements of the eyeball are limited

between the frontal sinus and the ethmoid labyrinth. The newgrowth had mainly been located above the eyeball and somewhat behind it, the floor of the frontal sinus being partially destroyed. The osteoma was extracted with comparative ease; a certain effort was required only in a limited area at the site of its attachment.

The osteoma is most likely to occur in the frontal sinus (see Figs. 38, 39, 43 and 44) or in the ethmoid labyrinth (Figs. 45 and 46), and in the majority of cases it grows towards the orbit to produce an orbital osteoma; it rarely penetrates into the cranial cavity to form a cranial osteoma.

In the former case the symptoms are basically disturbances in the organ of vision, in the latter case cerebro-cranial disorders may be the principal manifestation.

Ophthalmic symptoms. The principal symptom in the organ of vision is the protrusion and displacement of the eyeball, of which the patient usually complains to an ophthalmologist. These symptoms develop slowly, which is in complete accordance with the slow progress of osteoma. T. Bornhaupt stated as early as 1882 that the direction of eyeball displacement gave a clue to determining the position of the tumour. For example, in osteoma of the frontal sinus the eyeball is usually displaced downward and outward; an osteoma growing from the ethmoid labyrinth into the orbit displaces the eyeball forward and outward, and the presence of

a newgrowth in the maxillary sinus produces a forward and upward displacement. It should be borne in mind, however, that a maxillary sinus osteoma growing forward pushes the facial wall of the maxillary sinus and the anterior portion of the orbital floor upward, which may give the impression of the eyeball being pressed deeply into the orbit. A sphenoid sinus osteoma pushes the eyeball straight ahead: this, however, is observed only when the tumour invades the orbital cavity to a considerable extent or when the deeper portions of the orbit are pressed forward.

If the tumour invades several cavities the direction of eyeball displacement is an inadequate reason for a conclusion regarding its location. Displacement of the eyeball may be concurrent with limitation of its mobility in the opposite direction, i.e., toward the tumour. Contrary to the opinion of some specialists such limitation depends on purely mechanical factors, rather than on a muscle lesion, just as the drooping of the upper eyelid sometimes observed in frontal sinus osteoma can hardly be caused by affection of the muscle itself.

Diplopia caused by eyeball displacement is rarely found with osteoma. The reason is that gradual displacement of the eyeball causes the light-perceiving elements of the eye to adjust themselves to the new conditions. Some researchers believe that the absence of diplopia is associated with the deterioration of vision in the displaced eye, and the latter with astygmatism caused by pressure on the eyeball in one and the same direction. Following the removal of the tumour, when the eyeball returns to its normal position and regains its normal shape, astygmatism disappears.

Cases of lacrimation caused by the pressure of an osteoma on the naso-lacrimal duct are also observed. In a case described below (case report 22), the removal of "dead osteoma" from the ethmoid labyrinth was followed by the cessation of lacrimation.

Very dangerous are ulcers of the cornea, which often produce its perforation and even lead to complete destruction of the eye. The development of ulcers is facilitated chiefly by the loss of sensitivity in the cornea and marked exophthalmos as a result of which the cornea inadequately covered by the eyelids is deficient in moisture, and becomes subject to various injuries. In certain cases inadequate moistening of the cornea is associated with decreased activity of the lacrimal gland when compressed by a frontal sinus osteoma.

An osteoma usually produces no changes in the refractive media of the eye. In some cases hyperemia of the optic disc, inflammation of the optic nerve or a choked disc are found.

If an osteoma is accompanied by an empyema of the paranasal sinus or its cystoid distention with subsequent suppuration, the picture of the principal disease will be completely obliterated. Besides the above-mentioned symptoms a typical phlegmon of the

orbit sometimes develops to produce marked ophthalmic symptoms. In case an osteoma is joined by a chronic purulent inflammation in a sinus a fistula may develop on the upper eyelid or at the inner canthus. This will complicate differential diagnosis of a lacrimal sac fistula; it should be remembered that the latter is commonly found under the internal ligament. Irrigation of the lacrimal passages and their X-ray photography with a contrast medium are very important for diagnosis.

Nasal and paranasal sinus symptoms. Obstructed nasal respiration and nasal hemorrhage indicate either an osteoma of the ethmoid labyrinth growing into the nose, or an osteoma of the nasal cavity proper. In such cases rhinoscopy makes it possible to reveal a narrowing of the nasal cavity, usually unilateral, caused by the pressure of a bony tumour. Osteomata of the frontal sinus or ethmoid labyrinth which have not grown into the nasal cavity cause no symptoms as a rule, and in such cases rhinoscopy is of little help.

In cases where an osteoma obstructs the natural orifice of the frontal sinus (ostium naso-frontale) it contributes to the development of a mucocele (see Chapter IV). A simultaneous existence of an osteoma and a mucocele aggravates the process of atrophy and resorption of the bony walls of the sinus.

Cranio-cerebral disorders may be observed when an osteoma extends to the cranial cavity, i.e., with the so-called cranial osteoma. Their symptoms are caused by pressure on the brain, mostly on the anterior surface of the frontal lobe.

Loss of memory, more or less severe headaches, convulsions in the extremities and, finally, fits of epilepsy are the major symptoms found in patients with a cranial osteoma producing compression of the brain substance.

Case report 19. Patient G., female, aged 63, hospitalised in grave condition for persistent suppurative fistula in right upper eyelid. In addition, dense tumour felt on palpation at inner angle of right orbit. According to familial evidence tumour developed 5 years ago. On examination: right eyeball markedly protruding forward and displaced down- and outwards, its mobility limited, cornea transparent, anterior chamber shallow, pupil of round form; ocular fundus produced no ophthalmoscopic image; acuity of vision 0.2. Left eye without marked changes, acuity of vision 0.5. An X-ray examination of both frontal sinuses, the right ethmoid labyrinth and the right-side nasal cavity revealed a large tumour of bony consistency invading also the entire right orbit.

Within a few days of admittance the patient was found to have ataxia, vomiting, Babinski's symptom and occipital rigidity. Death followed shortly. Dissection revealed a large bony formation invading both frontal sinuses, which had penetrated into the cranial cavity and caused compression of the frontal lobes of the brain. Death was caused by an abscess in the right frontal lobe of the brain and purulent meningitis of the base of the brain.

Course of osteoma. A paranasal sinus osteoma grows slowly and sometimes years pass before its symptoms become apparent. The fastest growth is noted in pubescence and puberty, whereas in advanced age tumour growth is very slow.

The development of an osteoma falls into three periods: the first, or rudimentary period coincides with the formation of the paranasal sinuses; the second, or symptomless period continues until the complete formation of the paranasal sinuses, as is the case in the report described below (case report 20); the third period is characterised by marked symptoms.

Osteoma is sometimes accidentally found in an X-ray examination.

Case report 20. Patient K., female, aged 40. In 1932 visited an eye clinic to select eyeglasses for her son, complained at the time of a bony outgrowth at the inner margin of the right orbit. A knobby prominence of bony consistency could be palpated at the right superointernal margin of the orbit. No other pathological changes in the eyes were noted. It was only X-rays that showed a large osteoma in the right frontal sinus and ethmoid labyrinth. The patient, however, was lost sight of for a time and reported again only in 1946, i.e., fourteen years later, for examination, which revealed marked exophthalmos and displacement of the eyeball.

This case is evidence that even large osteomata may show no symptoms for a long time and be discovered quite accidentally.

In the two cases of a giant frontal sinus osteoma observed by Bedoni in 1957 the disease was also almost symptomless. Thus, in the first case, where an osteoma the size of a small lemon had penetrated into the orbit and the anterior cranial fossa, only an insignificant exophthalmos was noted, while in the other case, where the osteoma was the size of a chicken egg, the only complaint was of slight heaviness in the head.

In the majority of cases, the osteoma grows steadily, albeit slowly, and finally enters the third stage—the stage of apparent symptoms.

Diagnosis. Since the osteoma grows slowly, the subjective and rhinological symptoms are either unmarked or entirely absent. The tumour may be detected by common rhinoscopy only if it is located in the ethmoid labyrinth and has grown large enough to partially penetrate into the nasal cavity. In such cases the presence of a bony outgrowth, sometimes without a coat of mucous membrane and easily detectible by rhinoscopy, as well as the characteristic sound heard on probing and hitting the bony newgrowth indicate an osteoma in the ethmoid labyrinth. In those frequent cases where the osteoma grows towards the orbit and the results of endonasal examination are negative diagnosis is rather difficult.

An exceptionally important role in the diagnosis of osteoma is played by X-rays, which enable not only an accurate diagnosis based on the intense shadow and markedly delimited borders of the tumour, but also the determination of its size, its topographo-anatomical relationships with the adjacent regions, and its structure. These data are highly important for deciding on surgical interference and specific procedures.

The methods of X-ray examination are widely known. Its requisite element is examination of the skull in two projections: the anterior sagittal and the lateral. These are often supplemented by examination in an oblique projection after Rose's method modified by M. M. Baltin, which ensures a comprehensive survey of the whole tumour and its position with regard to the optic nerve canal.

An important factor of X-ray study is establishing whether the osteoma fills the entire paranasal sinus or is separated from the sinus walls by an air space indicating the absence of accretion with a wall. These data should be taken into account during an operation, which should be started in this particular region.

Below is a case where a plan for excising an osteoma was drawn up in accordance with X-rays.

Case report 21. Patient D., male, aged 31, hospitalised for palpebral edema and left-side exophthalmos of recent onset. Left eye: upper eyelid drooped, eyeball protruding forward, its upward, inwar dand outward mobility limited; cornea and refractive media transparent, ocular fundus without pathological changes, acuity of vision 0.2. Right eye normal. The X-ray film showed a bony tumour occupying the entire frontal sinus and partially invading the orbit; in the external, superior, intero-inferior, and medial portions it was separated from the frontal sinus wall by a narrow air space (see Fig. 46).

The patient was operated upon by the fronto-orbital method of opening the frontal sinus. Following the removal of the atrophied anterior wall of the frontal sinus, the borders of the osteoma came into view; the tumour extended very high upwards and rightwards, pushing out the interfrontal septum; outwardly it reached as far as the zygomatic process, though being out of contact with it. The osteoma was approached on all sides, the initial point of extirpation being the external portion at the malar bone, as well as the medial portion at the interfrontal septum, i.e., those portions in which air spaces had been revealed by X-rays. The extirpation became increasingly difficult as the elevator reached the central portion of the posterior wall of the frontal sinus. Inserting the instrument into the free space between the posterior surface of the osteoma and the posterior wall of the frontal sinus and stirring the tumour simultaneously to destroy or weaken its accretion with the posterior wall, it was possible to extirpate the tumour altogether. Following the extraction of the osteoma a small defect was found in the posterior wall of the frontal sinus, through which an intact dura mater could be seen. The size of the tumour was 55 by 44 by 30 mm, weight 31 g (see Fig. 44).

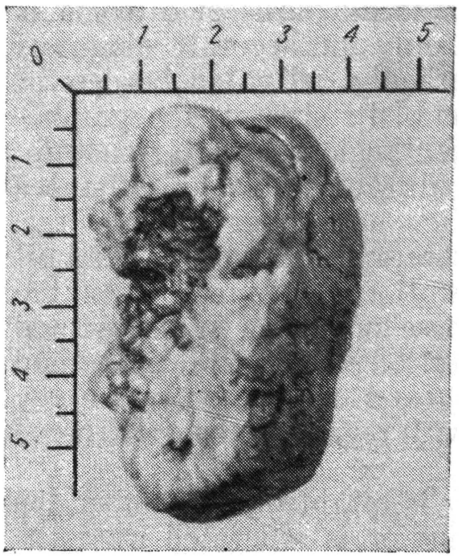


Fig. 44. The appearance and size of an excised osteoma (X-ray film is shown in Fig. 46)

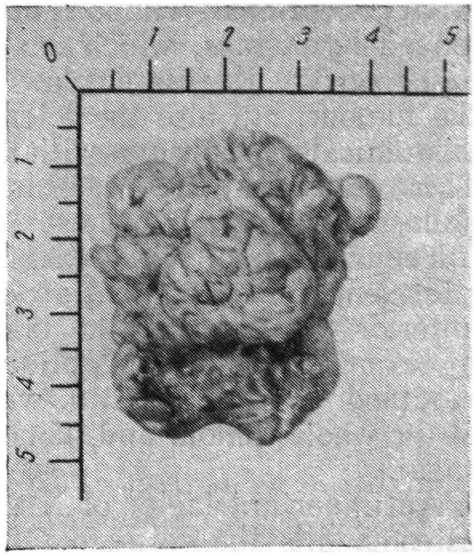


Fig. 45. The appearance and size of a "dead osteoma" extirpated from the ethmoid labyrinth

Treatment. The only remedy for an osteoma is surgery. With modern surgical techniques employed under sulfonamide and penicillin cover the mortality rate in operations for osteoma has dropped to 3 per cent. Some authors come out in favour of surgical interference for restoring the optic functions even where only part of the tumour can be removed. A. G. Khalfin, for example, recommends partial removal of the tumour located high up in the frontal sinus and simultaneously invading the orbit with disturbance of the optic functions, if it has no pedicle and has its base accreted with the sinus wall.

The choice of surgical methods depends on the extension and primary site of the morbid process. The orbital method of approach is the most reliable, while the fronto-orbital opening of the frontal sinus is used infrequently. For removal of an osteoma from the maxillary sinus or nasal cavity the transmaxillary approach, or Moore's operation, is advisable. If the osteoma is harboured deep in the orbit the approach to it, as some authors believe, can be facilitated by a temporary resection of the external orbital wall.

The detection of air spaces between the osteoma and the paranasal sinus walls, and location of its pedicle largely facilitate the extirpation of the tumour. The plan of the operation, therefore, should provide for a broad approach to the tumour pedicle (in order to bisect it), or to those areas where access is the easiest and where it is most convenient to begin the removal of the tumour.

"Dead osteoma" is the name applied to tumours freely lying in the paranasal sinus. These develop in cases of destruction of

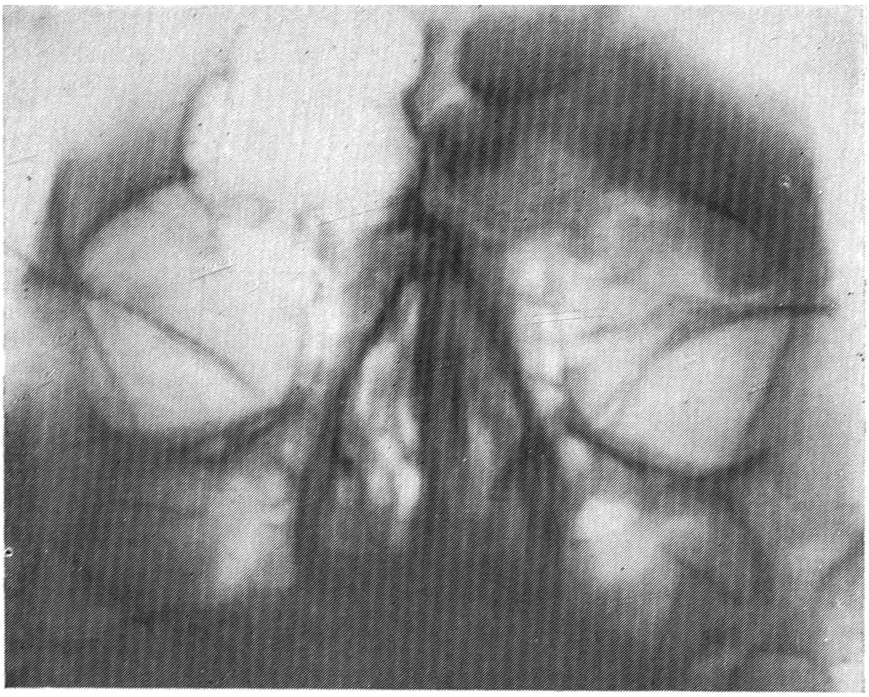


Fig. 46. A large osteoma of the left frontal sinus partially penetrating into the left orbit. In the external, superior, externo-inferior and medial portions, the osteoma is separated from the frontal sinus walls by air spaces. Clinical signs: forward protrusion of the eyeball, limitation of its upward, inward and outward mobility

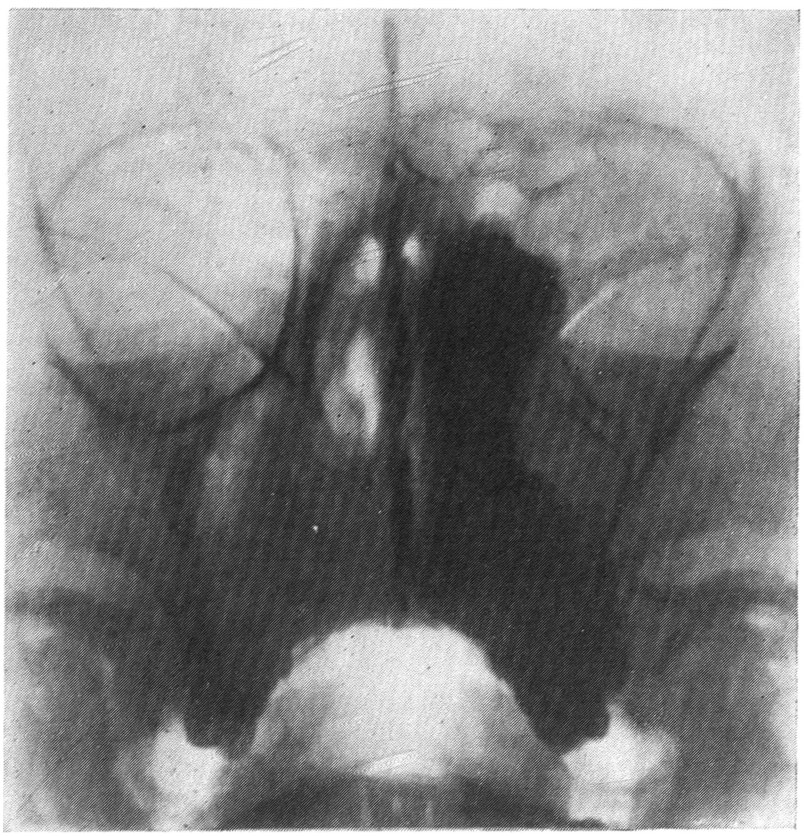


Fig. 47. Osteoma of the left-side ethmoid labyrinth

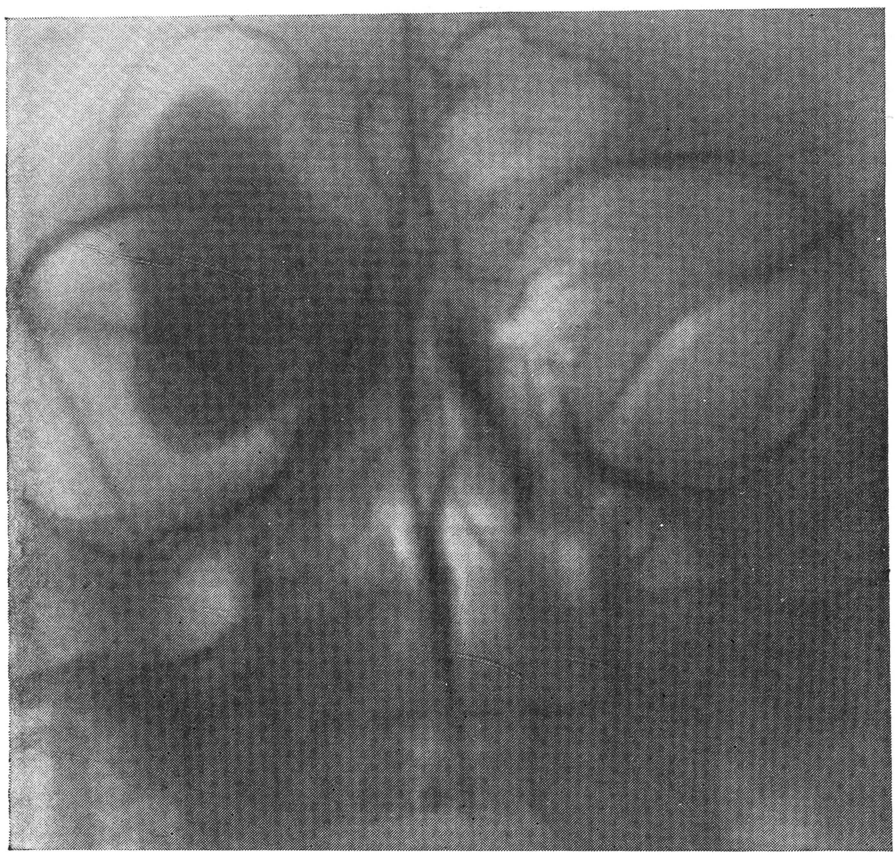


Fig. 48. Osteoma of the right ethmoid labyrinth penetrating into the orbit and frontal sinus. The clinical signs: exophthalmos, the right palpebral fissure is lower than the left

the osteoma pedicle not only in traumas, but also in empyemas which disturb its nutrition. A "dead osteoma" is a rare occurrence, and only twenty such cases, discovered in the ethmoid labyrinth where the pedicle is very likely to be torn off, have been described in the literature.

Below is a case report on a "dead osteoma" in the ethmoid labyrinth we have observed in our practice.

Case report 22. Patient S., female, aged 39. Complaints of anosmia and copious pus discharge from left side of nose. On physical examination, redness of skin at inner angle of left eye, tenderness on pressure applied to thickened bone, edema with redness of eyelids and excessive lacrimation. Eyeball normal. On examination of nasal cavity, entire upper and middle portions of its left side found invaded by bony tumour, almost devoid of mucous membrane and emitting a characteristic bone sound when struck with probe, with much pus. Anosmia.

An X-ray examination of the left side of the nose and the corresponding orbit revealed a deep shadow warranting the suspicion of a bony outgrowth.

The patient was subjected to an operation after Moore. The ethmoid labyrinth and left nasal cavity were found to contain an osteoma, which was extracted without particular difficulties, since it was unconnected with the surrounding tissues. Its size was 42 by 39 by 26 mm, and weight—27 g (Fig. 45). The operation was followed by cessation of pus discharge, recovery of the sense of smell and cessation of lacrimation.

As is evident from the above-adduced observations the surgical removal of an osteoma from the paranasal sinus serves to eliminate exophthalmos, restore eyeball mobility, stop lacrimation, increase the acuity of vision and liquidate all pathological symptoms associated with osteoma; at the same time this operation does not, in most cases, entail facial defects.

CHONDROMA

The chondroma of the nose and paranasal sinuses is an exceedingly rare phenomenon. Chiari observed only one case of a nasal chondroma among 60,000 patients. In the summary data of Moscow's clinics for 40 years, collected by Y. N. Malyutin, no cases of this tumour in the nose and paranasal sinuses have been found.

Out of the 131 cases of benign nasal tumours studied by Arslan only one was of a chondroma, while according to Hasslauer's statistics chondroma was observed in only four cases out of 281 (quoted from Y. M. Kossovich and T. P. Shuvalova).

Until 1928 only 54 cases of chondroma of the nose and paranasal sinuses had been described in the world's medical literature (according to data of Eckert-Möbius).

In Soviet medical literature only three cases of nasal and paranasal chondroma have been reported. The first was studied by P. I. Odinets at the E. N. T. clinic of Leningrad First Medical Institute in 1951, the second—by A. P. Averina at the E. N. T. clinic of the Ivanovo Medical Institute in 1953, and the third—by V. I. Amitin and N. V. Moskovskaya at the E. N. T. clinic of the Moscow First Medical Institute.

There is no unanimous opinion on the initial site of a nasal chondroma. Some authors attribute it to the nasal septum (Y. M. Kossovich and T. P. Shuvalova), others—to the bony formations of the paranasal sinuses, usually the ethmoid bone, less frequently the sphenoid and maxillary bones.

In the two cases mentioned above as observed by P. I. Odinets and A. P. Averina, the initial point of origin of a nasal chondroma was the nasal septum; in the third case it was the ethmoid labyrinth. In Dominik's observation of 1954, a chondroma had originated in the ethmoid labyrinth.

Pathological anatomy. There are two types of a chondroma: *the enchondroma*, growing from the endosteum or bone marrow to a considerable size and causing bone atrophy and resorption, and *the ecchondroma*, which arises from the periosteum.

Pathoanatomically, the chondroma is a tumour composed of various types of mature cartilaginous tissue, usually hyaline, less frequently reticular or fibrous cartilage. Macroscopically, it is made of nodular, tuberous and dense tissue of elastic consistency and composed of separate shapeless lumps interconnected by connective tissue layers pervaded by blood vessels. The chondroma is attached by a broad base and is immobile.

The microscopical structure of a chondroma (Fig. 49) differs from that of normal cartilage in having an irregular arrangement of cartilaginous cells in the matrix, various sizes of cartilaginous lacunae sometimes containing two or three cells, as well as in an entire absence of these lacunae in certain cases.

Retaining its benign character the chondroma sometimes tends to invade blood and lymphatic vessels where it disintegrates and produces metastases. This is particularly true of softened and slimy chondromata.

In certain cases areas of calcification (osteoid-chondroma) or bony tissue (osteochondroma) are found side by side with cartilaginous tissue.

The transition of a chondroma into a chondrosarcoma is observed where chondroblasts appear with marked polymorphism and all manifestations characteristic of a malignant tumour, i.e., infiltrative growth and predisposition to metastasis.

Fig. 49. Chondroma. Islands of hyaline cartilage separated by layers of cell-rich connective tissue

Clinical symptoms. Chondromata are mostly confined to young people between 20 and 30 years of age, but they are also encountered at a younger age, between 10 and 15. If the process develops quickly, microscopy of different portions of the preparation may reveal a chondroma transforming into a chondrosarcoma.

The tumour may be of variable size: from that of a hazelnut to that of a chicken egg and even as large as a child's head. In the above-mentioned case studied by V. I. Amitin and N. V. Moskovskaya a chondroma in the region of the external nose and cheeks, which had progressed slowly for 10 years, produced facial disfigurement with a swelling of the nose and marked outward displacement of both eyeballs, particularly the left. There was a substantial loss of vision, especially in the left eye, whose optic nerve was found to be completely atrophied. X-rays revealed extensive destructive changes in the nasal bones, both orbits, maxilla and ethmoid labyrinth.

The extension of the tumour, which usually originates in the ethmoid labyrinth and grows towards the sphenoid and frontal sinuses, cranial cavity, orbit and maxillary sinus, is accompanied by a variety of disorders.

The symptomatology of chondromata breaking from the paranasal sinuses into the orbit has much in common with that of orbital osteomata. Certain peculiarities of the clinical symptoms

of chondromata are associated with their usual origination in the ethmoid labyrinth.

The chondroma displaces the eyeball out- and upwards. If the tumour lies deep in the ethmoid labyrinth and especially in the sphenoid sinus it causes various optic disorders, among them exophthalmos, which is sometimes the first symptom of the disease. In one of the cases described in literature a chondroma not only caused grave ophthalmic symptoms, such as bilateral exophthalmos, optic nerve atrophy, abducens nerve paralysis, retinal edema and amaurosis, but set up a pathological process in the hypophysis, such as polyuria, amenorrhea, adiposis, etc.

Usually, however, the chondroma, like the osteoma, does not affect vision, despite eyeball displacement of variable type and degree.

The extension of a chondroma towards the cranial cavity gives rise to various intracranial complications, such as meningitis and brain abscess.

In view of the chondroma being liable to invading blood and lymphatic vessels metastases should be expected even in distal organs.

A highly interesting case of a chondroma has been reported in the Soviet literature by P. I. Odinets. It is given below.

Patient P., female, aged 69, initially applied to a rhinolaryngologist for a growing nasal obstruction caused by a dense newgrowth in the right side of the nose. Subsequently she was referred to an ophthalmologist in view of the symptoms prevailing.

The patient developed exophthalmos and eyeball displacement upwards and outwards followed by changes in the optic nerve with a certain loss of vision. The indistinct borders of the optic disc, dilatation and tortuousness of the veins, particularly in the macular region, led Professor of Ophthalmology V. V. Chirkovsky to suspect compression of the optic nerve and muscular funnel by a tumour. During two and a half years the patient was admitted four times to the E. N. T. clinic of the Leningrad First Medical Institute for surgical treatment. The first time, the tumour which had grown from the right ethmoid labyrinth was extracted by the endonasal method, and subsequent histological examination proved it to be a hyaline chondroma in the process of growth. In view of relapses the patient was subjected to four more external operations with a bilateral opening of the ethmoid labyrinth and maxillary sinus. Even after the last operation the prognosis was doubtful.

Diagnosis. Because of the density, elasticity and tuberosity of the chondroma it can be easily differentiated from inflammatory hyperplasia and soft tumours.

The differential diagnosis between chondroma and osteoma is more difficult, particularly if the former contains calcified portions (osteoid-chondroma) or bony tissue (osteochondroma). The

absence of bleeding and the possibility of puncturing the tumour speak in favour of chondroma.

The chondroma has very much in common with a dense fibroma. A pure chondroma, free from calcification and ossification, produces a less intense shadow on an X-ray film than does an osteoma.

Prognostication is doubtful when the tumour pierces the cribriform plate and hopeful when it arises from the nasal framework.

Treatment. The conservative methods of treatment of a chondroma including X-ray and radium therapy, have proved of little efficacy. The most helpful treatment is surgery, and the sooner it is undertaken the less will be the danger of a relapse.

The surgical approach to extirpation of a chondroma is the same as for an osteoma, i.e., a transmaxillary operation alone or in combination with the opening of the frontal sinus. If it is impossible to extract the tumour entirely it should be removed partially in order to avert intracranial complications.

OSTEOCHONDROMA

Plain osteochondromata within the facial skeleton, in the nose and paranasal sinuses in particular, are exceedingly rare. The most favourite site of these benign tumours are the tubular bones.

In 1956, R. A. Minchin reported an osteochondroma of the maxillary sinus, nasal cavity and nasopharynx. It was effectively treated by Moore's operation followed by gamma-ray therapy.

In 1955, Y. M. Kossovich and T. I. Shuvalova made a highly interesting study of a chondroma growing from an extensive chondroangioma of the paranasal sinuses, which had developed under the effect of X-ray therapy administered in two sessions in a total dose of 8,064 r, and invaded the ethmoid labyrinth, frontal and sphenoid bones.

FIBROMA

Fibromata are rarely encountered in the nose; they are usually hard formations (fibroma durum; Fig. 50) arising from the periosteum and therefore called periosteal fibromata. Soft, papillary tumours of this kind are also encountered.

Pathological anatomy. Macroscopically, the hard fibroma is a pale-red compact tumour of cartilaginous and even bony consistency with a smooth surface coated with a mucous membrane. The tumour is usually attached to the underlying tissue by a broad base or, less frequently, by a slender pedicle. It sometimes contains calcified and ossified portions which crunch when cut.

Microscopical examination reveals a dense connective tissue consisting of rough, hyalinised fibre bundles and few cells.

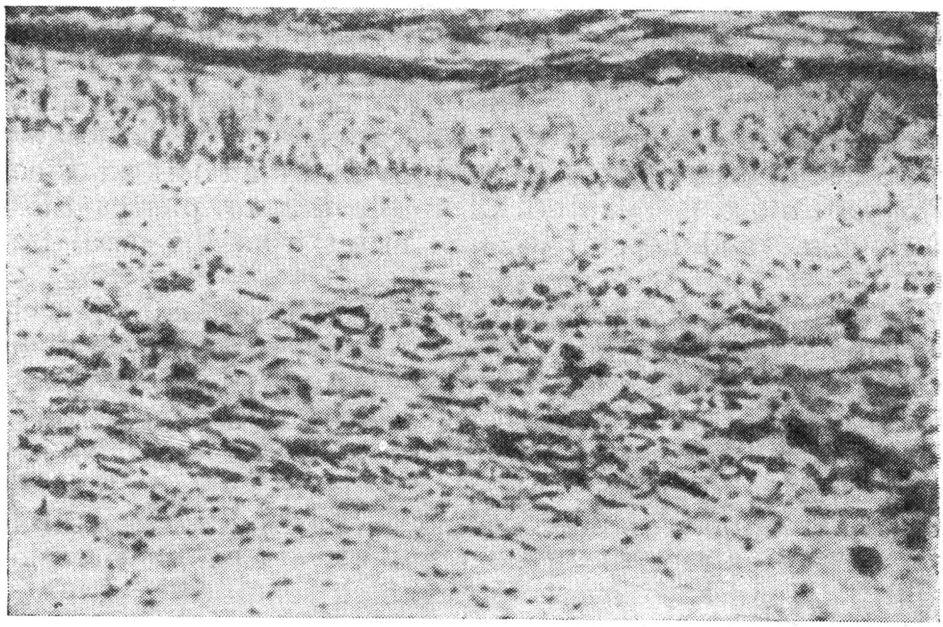


Fig. 50. A dense fibroma consists mainly of dense collagenous tissue (after Foot)

Clinical symptoms. The clinical course of a fibroma is like that of a malignant tumour on account of its rapid growth and penetration into the paranasal sinuses and the orbit.

Fibromata confined to the nasal cavity produce nasal obstruction and often cause copious nosebleed, whereas their penetration into the paranasal sinuses and the orbit may be accompanied by exophthalmos, lacrimation and optic disorders due to compression of the optic nerve.

In the paranasal sinuses fibromata are found even less frequently than in the nose; they are usually found in the maxillary sinus.

The symptoms of a fibroma in this sinus become apparent rather late, after the tumour has grown to a considerable size. Even in that case, however, the only symptom of a fibroma which has not yet filled the entire maxillary sinus may be pain caused by tumour pressure on the orbital floor where the infraorbital nerve is lodged.

If the newgrowth subsequently fills the entire maxillary sinus it produces deformation of the facial skeleton by depression of the orbital floor, flattening of the hard palate, protrusion of the facial wall of the sinus, and bending of its medial wall towards the nose. This is attended with upward and outward displacement of the eyeball and optic disturbances. A maxillary sinus fibroma, however, may also take a perfectly innocent course. V. O. Okulov, for instance, has described a hard fibroma of the

maxillary sinus which had been in progress for 12 years without penetration into the adjacent organs.

Fibromata of the sphenoid sinus and ethmoid labyrinth are extraordinarily rare; if they do occur they produce a complicated clinical syndrome in the orbit and eyeball.

Diagnosis. Although the final diagnosis should be based on a histological examination, a tentative diagnosis should always be made with a view to a chondroma, with which the fibroma has much in common in outward appearance and consistency. One should only remember that chondromata always arise in the paranasal sinuses wherefrom they penetrate into the nasal cavity, whereas fibromata have their primary focus in the nasal cavity.

The final diagnosis should be based inter alia on X-ray examination of the paranasal sinuses.

The outlook may be favourable only upon complete extirpation of the tumour.

Apart from the osteoma, chondroma and fibroma, there are other innocent newgrowths of connective-tissue origin, such as the *lipoma* and *myxoma*. These tumours are rarely found in the nose and paranasal sinuses, since so far as the nose is concerned, its mucosa as well as the paranasal sinuses are devoid of adipose tissue.

Rather than being an independent tumour the myxoma is commonly a fibroma, lipoma or chondroma undergoing mucoid degeneration.

FIBROMYXOMA

The fibromyxoma, i.e., a myxomatous fibroma of the maxillary sinus, was described in 1956 by M. G. Panasyuchenko. Macroscopically, the tumour consisted of nodular elastic formations of variable form and size, and histologically—of round, spindle-shaped and stellate cells interconnected into a delicate meshwork. The tissue stroma harbouring the cells was made of a mucoid substance. The peripheral portions were found to contain irregularly arranged bundles of fibrous connective tissue abounding in cells.

This fibromyxoma extended from the maxillary sinus into the orbit, pterygo-palatine fossa, nasal cavity and especially markedly towards the oral cavity.

The treatment was by Denker's operation with a preliminary ligation of the external carotid artery.

A teleangiectatic fibroma extracted through the posterior ethmoid cells was described in 1958 by Demkov of Czechoslovakia. It had developed from the remnants of a tumour following its endonasal removal. This author also described a giant osteo-

fibroma of the maxillary sinus and ethmoid labyrinth, for which it had been necessary to resect the maxilla.

The benign tumours of fibro-epithelial character also include adenoma, epidermoid, papilloma and mucoid.

ADENOMA

It will be recalled that the morphological structure of a tumour does not always reveal its character. Adenomata are particularly illustrative in this connection since they are found in the nasal cavity in the following two forms which drastically differ in course and clinical picture: (1) genuine innocent adenomata (adenoma simplex), which are small polyp- or papilloma-shaped tumours attached by a broad base to the nasal septum or the anterior end of the middle nasal turbinate; and (2) malignant destructive adenomata (adenoma malignum), which fill the entire nasal cavity and considerably destroy the facial skeleton by growing into the surrounding parts of the visceral cranium.

Pathological anatomy. Macroscopically, the adenoma appears as a red, pale-pink or grayish-yellow tumour of soft consistency, sometimes with a smooth and sometimes a tuberous surface. The location of benign tumours on the nasal septum or the anterior end of the nasal turbinate is attributable to the abundance of glands in these areas.

Microscopical examination reveals a tumour composed of glandular tissue with a tubular or alveolar structure. The connective tissue serves as a framework laid out around the glandular formations and covering the surface of the tumour. The growth of an adenoma completely depends on its glandular epithelium which in appearance and number of layers somewhat differs from normal. In cases where the epithelial cells are arranged in several layers the gland lumina are either hardly noticeable or absent altogether, while in the case of a unilaminar cell arrangement the lumina are wide. Adenomata are covered with a mucous membrane constructed after the type of the columnar epithelium, in places becoming spheroidal, and having the membrana propria separating the epithelium from the connective tissue. As to its functional characteristics, the adenoma produces no secretion, as distinct from normal glandular formations. The gland lumina sometimes contain concretions, and the gland itself—cystose cavities (cystadenomata).

Incidence. Adenomata are rarely encountered in the nose. For example, according to data for 20 years, collected by Y. N. Malyutin from the archives of Moscow hospitals and clinics only one case of adenoma was found among 125 cases of malignant tumours of the nose and paranasal sinuses. L. N. Natanson described two cases of adenoma observed in L. I. Sverzhevsky's

clinic, and collected 38 cases of nasal adenoma from the literature up to the year 1935, which, together with his own observations and those by A. O. Kovarsky and others, makes a total of 40.

Clinical symptoms. Patients with a benign adenoma suffer only from nasal obstruction and nosebleed, whereas destructive tumours penetrating into the paranasal sinuses and the orbit may cause exophthalmos, limitation of eyeball mobility and other changes.

Diagnosis. Although final judgement should be based on a histological examination the discovery of a pale-pink soft tumour is suggestive of an adenoma.

The course of an adenoma is usually slow, particularly of the second-type tumours which, though lacking infiltrative growth, often invade the surrounding organs—the paranasal sinuses and the orbit—and tend to relapse.

L. N. Natanson reports an exceedingly rare and interesting case of a malignant adenoma in a female patient who was under medical observation for 10 years; during this period she was seven times admitted to a clinic for surgical interference for a relapse. The final operation was an exenteration of the orbitosinual region after S. S. Golovin, undertaken in view of the extension of the tumour to the orbit.

Prognosis is quite favourable for the first-type adenomata, and doubtful with regard to the destructive forms on account of the tumour penetrating into the adjacent organs, including the cranial cavity, with considerable destruction of the bony framework.

Treatment is exclusively by surgery, which should be radical if relapses are to be avoided. X-ray and radium therapy have proved of little effect.

EPIDERMOID
(TRUE CHOLESTEATOMA)

These tumours arising in proximity to air-filled cavities develop from the meninges, frontal and temporal bones of the skull, into which they usually grow. Sometimes, however, a true cholesteatoma grows from a paranasal sinus into the orbit.

Pathological anatomy. Seen with the naked eye the epidermoid consists of lustrous laminae stratified as in an onion, nucleus-free cells and cholesterol crystals, while its central portion is a pulpy mass.

Histologically, the epidermoid sac consists of an external layer of thin connective tissue and an internal layer of stratified squamous epithelium.

Clinical symptoms. Epidermoid is a rare disease, and not all of the 27 cases described in literature are authentic; most of them (see Chapter III) are pseudo-rather than true cholesteatomata.

Their extension to the orbit may cause symptoms of eyeball displacement, lacrimation and impairment of vision.

Diagnosis. It should be kept in mind when making a diagnosis that an epidermoid may be mistaken for a pseudocholesteatoma, osteoma and mucocele.

A quick aggravation of inflammatory symptoms in the eyelids, the presence of suppurative signs in the nose and the mixture of pus with cholesteatomatous masses are pathognomonic of a pseudocholesteatoma. The X-ray examination permits one to discard the presumption of osteoma and mucocele, but the diagnosis can be verified only at operation or by a histological examination.

The only method of treatment is surgery.

PAPILLOMA

Hard and soft papillomata are encountered, of which 60 and 38 cases have been reported, respectively. They usually originate in the nasal cavity; among the paranasal sinuses the antrum of Highmore and the ethmoid labyrinth are the most liable to this affection.

MUCOID

The mucoid, or fibro-epithelial cyst, is a rare disease. Like the papilloma, the mucoid causes no orbital complications since it is not apt to grow into the orbit.

The above-described innocent tumours are often found in combination with each other and with malignant neoplasms. There have been described osteofibromata growing primarily towards the orbit (fifteen cases in all), fibroepitheliomata, i.e., hard papillomata which take their origin from the nose and penetrate into the maxillary and frontal sinuses, myxofibromata, etc.

L. T. Levin and A. M. Zibert have described an exceedingly rare case of fibro-osteosarcoma (fibro-osteosarcoma teleangiectaticum) which produced an ugly facial deformity; the tumour was the size of a large chicken egg and had invaded the entire left side of the nose, forming an ingrowth in the right maxillary sinus and the right orbit.

PSAMMOMA

Psammomata of the paranasal sinuses and the orbit are very rare; only 8 cases have been described, 6 of them by the Soviet specialists E. F. Levkoyeva (1930), V. L. Kanevsky (1936), N. Y. Ogneva (1946), and A. G. Likhachev (1946). These authors, too, have only one case each to their credit, excepting E. F. Lev-

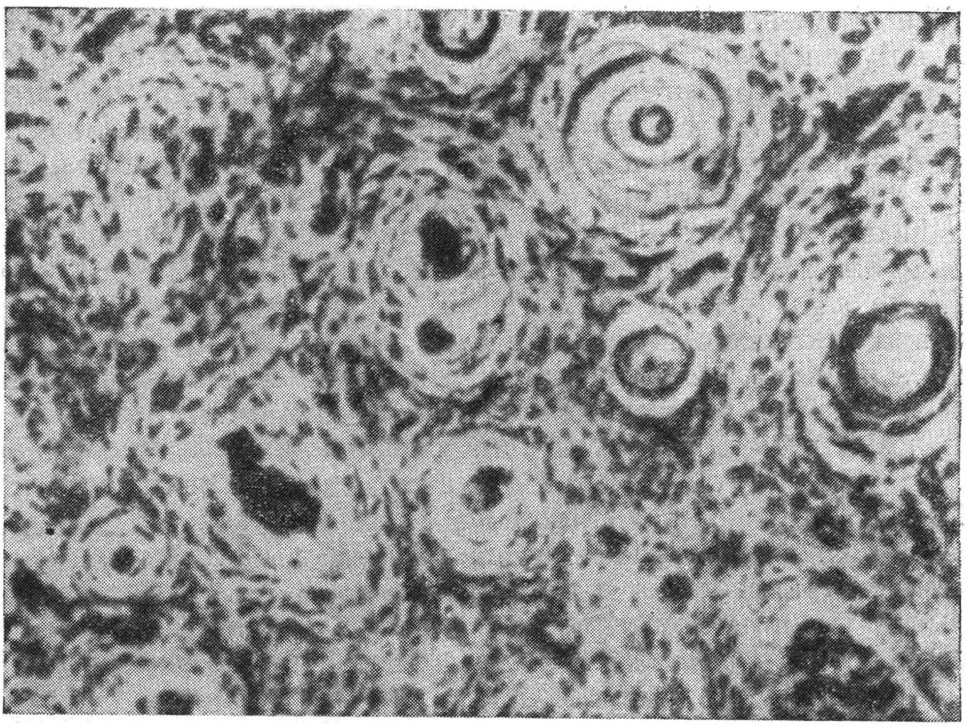


Fig. 51. Psammoma. The psammomatous type of meningeoma with small eye-shaped, usually calcified bodies known as "psammoma corpuscles" (after Foot)

koyeva who reported three cases which she had observed at the Helmholtz Institute of Ophthalmology between 1924 and 1928.

In expert opinion psammomata develop from a meninx and grow towards the optic nerve, or first penetrate into a paranasal sinus and thence into the orbit.

The psammoma, like the adenoma, is marginal in regard to malignancy. The histogenesis of psammoma is variously interpreted not only by different researchers but even by the same authors who attribute it either to a fibroma or to tumours arising from the vascular endothelium.

Indeed, histologically the psammoma is either a fibroma or an endothelioma with hyalinised vessel walls, or a carcinoma with homogeneous calcareous inclusions, i.e., psammoma particles formed by deposition of lime salts in the indurated and hyalinised bundles of the connective-tissue stroma, in clogged blood vessels and atrophic endothelial cells (Fig. 51).

Thus, the psammoma may be called an independent tumour only conventionally, since in some cases it may be a fibropsammoma (fibroma psammosum), as in V. L. Kanevsky's report, in others—a fibrosarcomatous psammoma, as in E. F. Levkoyeva's observation, or a psammomatous endothelioma, etc.

The above-mentioned cases were observed at the age of 11 to 13; only once was a psammoma found in a 30-year-old patient.

The clinical picture of a psammoma growing from the paranasal sinus into the orbit is characterised by symptoms of mechanical compression of the eyeball, such as exophthalmos, sidewise displacement of the eyeball, etc., as well as by a swelling at the inner orbital angle. A painless and dense, though rather elastic and resilient prominence is felt on palpation in this region.

These signs permit a differential diagnosis between an osteoma and a mucocele. Thus in E. F. Levkoyeva's and A. G. Likhachev's studies the preoperative diagnosis was one of a mucocele, while in another observation by E. F. Levkoyeva the diagnosis wavered between an osteoma and a mucocele; in N. Y. Ogneva's observation, however, the psammoma was identified as an osteoma. Rhinoscopy helps in diagnosis only when the tumour has invaded the nasal cavity; macroscopically the psammoma appears as a knobby, granular pink tumour.

X-ray examination shows an intense shadow suggesting an osteoma; in a few cases, however, it has led to a presumption of mucocele.

The course of the process, even when the psammoma particles develop with an endothelioma and fibrosarcoma (see case report 23), is usually slow (2 or 3 years), which attests to some extent its innocence.

Prognosis is basically hopeful, save for individual relapses. The treatment is surgical.

Below follows a case observed by M. M. Baltin and reported by E. F. Levkoyeva of the Helmholtz Institute of Ophthalmology.

Case report 23. Patient T., female, aged 13; complains of marked protrusion of right upper eyelid. Right eyeball displaced out- and downwards to the level of cheekbone, i.e., almost 3 cm, with exophthalmos (8 mm) and limitation of eyeball mobility upwards and in both lateral directions.

Very hard and tuberous newgrowth extending into depth of orbital cavity revealed on palpation of supraorbital margin. Refractive media transparent, retinal veins dilated, acuity of vision 0.4, with correction 0.75-0.9. Left eye without pathological changes.

An X-ray examination indicated a tumour in the right frontal cavity, the orbital floor at right being completely destroyed and the tumour invading the anterior cranial fossa. The diagnosis was one of a mucocele of the right frontal sinus, possibly a psammoma. In addition to destruction in the right orbital floor and atrophy of the posterior wall of the frontal sinus with exposure of the dura mater, the operation revealed a tumour-like mass composed of individual crumbling particles. A histological examination established a fibrosarcoma with homogeneous calcareous inclusions. Such tumours, according to the pathohistologist's evidence, are characterised by slight malignancy.

NEURINOMA AND NEUROMA

Tumours arising from nerve tissue cells, such as neurinoma and neuroma, attack the nose and paranasal sinuses very rarely.

Only isolated cases of a nasal neurinoma have been described in the literature [G. M. Glushkovsky, B. F. Zasedatelev, T. N. Preobrazhenskaya, I. M. Frischmann, I. I. Tsypkin; Gaillard, Lafon (1955), Harkins (1949), Mittelbach and Woletz, Eggston, and Wolff].

So far as neuromata of the nose and paranasal sinuses are concerned, A. V. Akelaitite, who has reported one case of a neuroma of the ethmoid labyrinth penetrating into the maxillary sinus and nasal cavity, notes that he was unable to find a single case report on this nasal tumour in the literature.

Pathological anatomy. Nasal neurinomata develop from Schwann's nerve sheaths and neuromata (gliomata) from rudimentary neuroglia, harboured in the nasal cavity apparently since the embryonal period.

In a histological examination of neurinoma T. N. Preobrazhenskaya found the tumour to consist of bundles of spindle-cells with small oval nuclei. These bundles went in every direction, forming vortical structures. No cellular polymorphism and mitotic division figures were discovered.

Microscopic examination of neuromata by A. V. Akelaitite has revealed large monomorphous cells with mitotic figures arranged within a thick meshwork of thin fibrils. The discovery of these phenomena has led him to conclude that neuromata apparently consists of embryonal cells of the central nervous system. Their clinical symptoms are quite variable and depend entirely on which portions of the nose and which paranasal sinuses have been affected, as well as on the direction of tumour growth.

In the report by A. V. Akelaitite a neuroma of the ethmoid labyrinth entailed a phlegmon of the la crimal sac. T. N. Preobrazhenskaya observed in an X-ray film a marked shadowing of the left-side ethmoid cells, the medial portion of the left frontal sinus and the maxillary sinus on the same side; rhinoscopy revealed hypertrophy of the anterior end of the left middle turbinate and obstruction of the left middle nasal meatus by a dense formation with a purulent surface; ophthalmological examination showed moderate exophthalmos with the eyeball slightly prominent and displaced downwards, limitation of upward movements of the eyeball, edema of the left upper eyelid, astigmatism and a slight loss of vision.

Surgical interference by means of trephination and the frontoethmoidal region showed the tumour to have emanated from the ethmoid labyrinth and grown into the left orbit, to which the above-mentioned optic symptoms may be attributable.

CEMENTOMA

This type of innocent newgrowth usually takes its origin from a tooth root, for which reason it is classed among odontogenous tumours; cementoma in the paranasal sinus is an exceptionally rare occurrence.

I. L. Kruchinina of the E. N. T. Clinic at the Therapeutics Department of the Moscow Second Medical Institute has reported a rare case of cementoma originating from the ethmoid labyrinth in a five-year-old child (Fig. 52). Histological examination showed the presence of connective-tissue fibres which were found to contain round and often stratified cementicles participating in the formation of tooth cement (Fig. 53).

Clinically the child was found to have left-side exophthalmos and considerable outward displacement of the left eyeball. The bridge of the nose was expanded, and a compact formation was palpated at the inner angle of the left eye. The left side of the nose was totally obstructed by a dense, almost immobile and tuberous formation covered with an intact mucous membrane. X-ray examination revealed a newgrowth occupying the cells of the left-side ethmoid labyrinth, which proved to be dilated and from which the tumour extended to the left maxillary sinus.

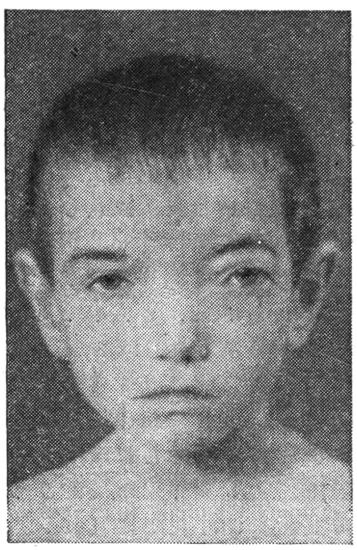


Fig. 52. Cementoma of the ethmoid labyrinth in a 5-year-old child with a left-side exophthalmos and considerable outward displacement of the eyeball (I. L. Kruchinina's report)

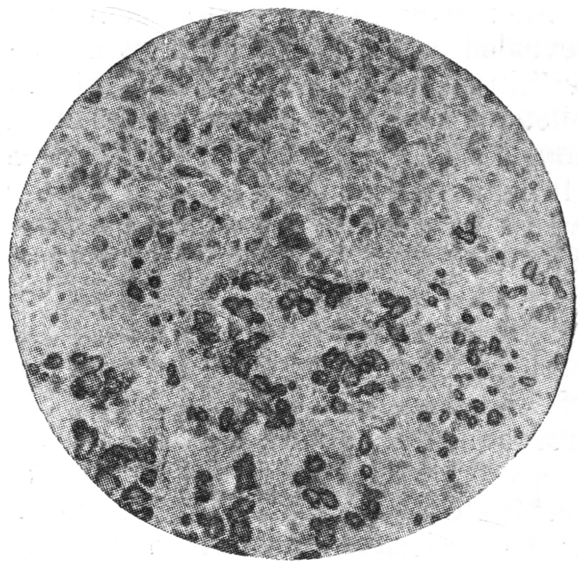


Fig. 53. The same case. Histological examination: connective-tissue fibres containing round, often stratified, cementicles

The left orbit was narrowed by pressure of the newgrowth on its internal wall.

The treatment carried out by I. L. Kruchinina consisted in a radical opening of the left maxillary sinus through which the tumour was extracted.

The cementoma cannot be identified clinically, and is usually mistaken for an odontoma or an osteoma (A. Ryvkind).

MALIGNANT NEOPLASMS OF THE NOSE AND PARANASAL SINUSES INVADING THE ORBIT

The incidence of extension of malignant tumours from the paranasal sinuses to the orbit may be assessed from the data given below. At the Ukrainian Institute of Radiology and Oncology forty-two patients with tumours of the paranasal sinuses extending into the orbit received treatment during ten years, whereas the number of out-patients with newgrowths in the paranasal sinuses without affection of the orbit was two and a half times greater (I. I. Merkulov). Referring to materials of the Leningrad Institute of Oncology, A. V. Afanasyeva points out that out of 182 cases of maxillary tumours 35, i.e., 19.2 per cent, had penetrated into the orbit. Öhngren reported 41 cases of newgrowths in the maxillo-ethmoidal region penetrating into the orbit out of 144, i.e., 28.4 per cent. According to Syk 25 out of 50 tumours of the paranasal sinuses, i.e., 50 per cent, had invaded the orbit. A high proportion of malignant tumour invasions of the orbit is also reported by otorhinolaryngologists; according to data of the L. I. Sverzhevsky Clinic 14 out of 21 tumours had extended from the paranasal sinuses into the orbit.

In view of the frequency of secondary orbital tumours growing from the paranasal sinuses, the ophthalmologist should be familiar with the forms and clinical symptoms of malignant newgrowths of the paranasal sinuses as the primary source of orbital affection.

Efficient cancer control, the wide network of oncological clinico-prophylactical centres, and accurate registration of cancer cases in the U.S.S.R., enable determination of the incidence of the malignant growths in question in relation to the total number of oncological patients. Thus, according to data of the Leningrad Institute of Oncology maxillary carcinoma accounts for 1.8 per cent of the total cases of malignant neoplasms observed at the Institute during ten years. A similar proportion (1.8 and 2 per cent) is reported by New York and Swiss statisticians. In Nystrõm's materials, out of the 9,193 cases of malignant tumours in various organs and systems observed at the Institute between 1911 and 1913 newgrowths in the maxillary region were noted

in 101 cases, i.e., in more than 1 per cent of the patients. I. I. Merkulov considers that malignant tumours of the maxillo-ethmoidal region account for at least 2 per cent of the total cases of malignant neoplasms. So far as the absolute figures are concerned, 643 cases of malignant tumours of the nose had been found by I. Sendzyak in the literature up to 1912. More up to date statistics were collected by Marschik (800 cases) and Denker (441 cases of cancer of the nose and paranasal sinuses).

The literature of earlier years contains evidence by I. Sendzyak, who pointed out that carcinomata of the paranasal sinuses are more frequent than sarcomas. V. N. Shchechkin notes that the incidence of maxillary cancer is five times that of maxillary sarcoma, whereas in the nasal cavity this relation is reversed. The data furnished by individual authors and clinics (A. I. Feldman, D. I. Zimont, V. K. Suprunov, G. S. Bilinkis, G. A. Neuburg, Marschik, Chiari, Syk, Holmgren and Denker) and particularly the statistics of large institutions, which as the Leningrad Institute of Oncology, confirm this evidence.

Among exceedingly rare diseases is endothelioma, which some authors attribute to sarcoma, others, to cancer. Marschik found in the literature 60 cases of endothelioma, while in D. I. Zimont's materials endothelioma was discovered in 1 out of 37 cases of malignant tumours of the paranasal sinuses.

Among the cancer tumours the most common is the squamocellular cancroid or ossifying carcinoma originating, as some authors assert, from a metaplastically degenerated columnar epithelium of the sinus mucosa, such as in chronic sinusitis, as well as medullary carcinoma, a soft cell-rich tumour, containing a small quantity of connective tissue; scirrha with much connective tissue are rarely encountered in the paranasal sinuses. The high frequency of flat-celled carcinoma is due to metaplasia of the columnar epithelium in the paranasal sinuses for various reasons, as a result of which squamous cells are discovered along the periphery of the newgrowth (Y. N. Malyutin). Besides these forms, columnar-celled carcinomata are found arising from the columnar epithelium lining the paranasal sinuses, or from the glands of the mucous membrane.

Less frequently observed are basal-celled forms characterised by the growth of basal cells of stratified columnar epithelium with or without cornification.

Among the blended forms melanocarcinomata and adenocarcinomata composed of glandular tissue are sometimes encountered. The structure of adenocarcinomata is characteristically atypical, with epithelial polymorphism and newly-formed glands of no functional value. Their common site is the ethmoid labyrinth. Fibroadenomata with carcinomatous inclusions are also found in the paranasal sinuses.

An adequate picture of the histological structure of cancer tumours of the paranasal sinuses may be formed on the basis of D. I. Zimont's materials. The 25 carcinomata of the paranasal sinuses he had observed are classified as follows:

Squamocellular cancer with cornification	4
ditto without	5
Medullary cancer with cornification	8
ditto without	4
Basal-celled cancer	2
Melanocarcinoma	1
Carcinosarcoma	1

Besides the round-celled sarcomata there are also the spindle-celled sarcomata. Among the blended forms are fibrosarcomata (Fig. 54), chondrosarcomata (Fig. 55) and ossifying chondrosarcomata, chondrofibrosarcomata and lymphosarcomata (Figs. 56 and 57).

A. I. Pokrovsky reported a case of secondary orbital lymphosarcoma which had grown from the maxillary sinus (Fig. 57).

Metastases from malignant tumours of the nose and paranasal sinuses to distant organs are rarely found as the patient usually dies from cerebral and other complications and from cachexia before cancer particles are swept into the blood flow.

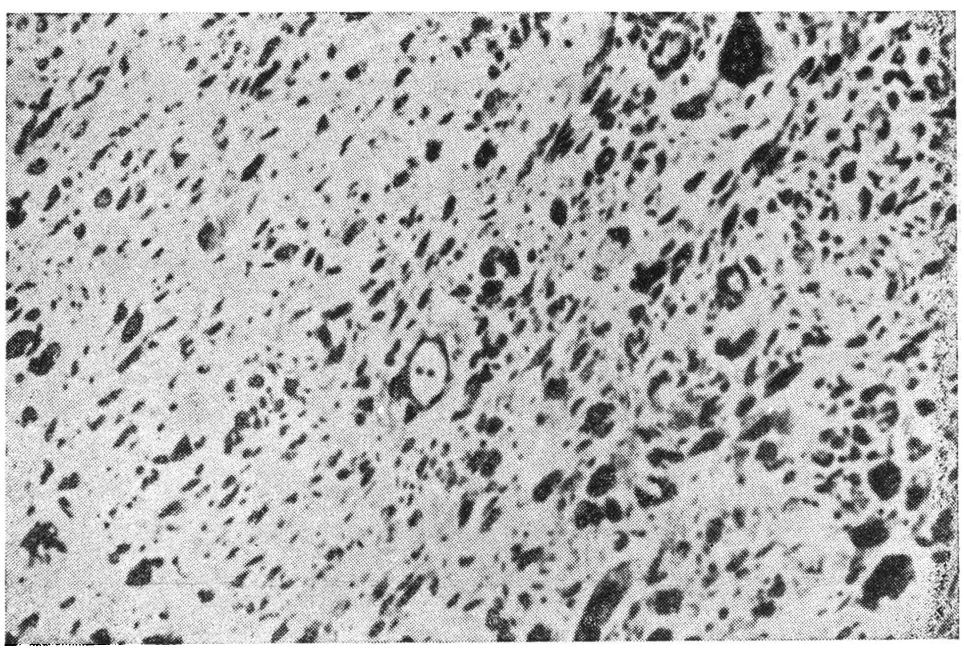


Fig. 54. Fibrosarcoma consists of markedly atypical fibroblast derivatives, many of a tremendous size. The tumour contains many cells and little fibrous tissue (after Foot)

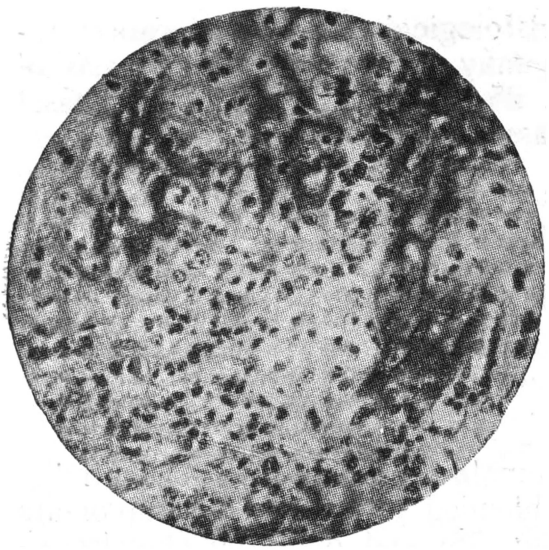


Fig. 55. Chondrosarcoma. Homogeneous layers of basal cartilage tissue are seen among the cells

The widely accepted view that malignant tumours of the paranasal sinuses rarely produce metastases in the regional submaxillary, cervical and retropharyngeal lymphatic glands is disputed by A. O. Vereshchinsky and other authors. A. O. Vereshchinsky believes that those who share this view have been led into error by the peculiarities of lymphatic drainage from the nose. The lymph from the posterior portions of the nose flows to the ganglions and glands of the retropharyngeal space, inaccessible to examination or palpation. Clinical examination can reveal

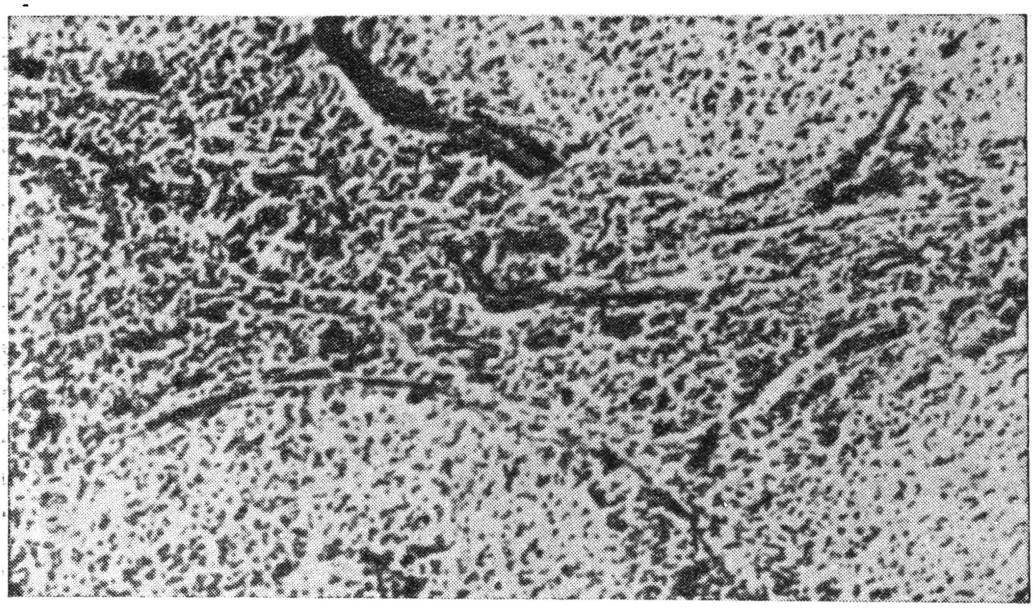


Fig. 56. Lymphosarcoma. A modular lymphosarcoma with giant follicles separated by underdeveloped pulp (after Foot)

only comparatively rare lymph deliveries from the anterior portions of the nose to the glands on the side of the neck.

The etiology and pathogenesis of malignant tumours are still unknown. Most theories evolved to specify the pathogenesis of tumours are largely concerned with the conditions of their growth rather than their causes. Thus, Cohnheim's theory of the embryonic origin of cancer is devoted solely to the problems of histogenesis, which is inadequate for clinical practice. Virchow's theory which connects the origin of malignant tumours with irritation is indefensible inasmuch as its supporters consider the newgrowth to be a wholly topical process (autonomy, autodynamics of tumour growth) and regard local irritation as the major factor of cancer etiology and pathogenesis.

Nor have we any serious evidence in favour of the infection (virus) theory.

The clinical manifestations of secondary malignant tumours occurring as a result of a blastoma penetrating from a paranasal sinus into the orbit are sufficiently marked. They consist of symptoms associated with a malignant tumour in one or another paranasal sinus and with a secondary affection of the orbit as a result of its invasion by a tumour growing from a paranasal sinus.

Malignant tumours are most frequently discovered in the maxillary sinus, in fact, in up to 65 per cent of the total cases (Figs. 57, 58, 59); the ethmoid labyrinth is attacked less often (10 per cent), while the sphenoid and frontal sinuses are even less liable to this affection.

According to the summary data of Laurent (1924), the relative incidence of affection of individual sinuses in 269 cases was as

Fig. 57. Lymphosarcoma of the maxillary sinus, orbit and surrounding regions (A. I. Pokrovsky's report)

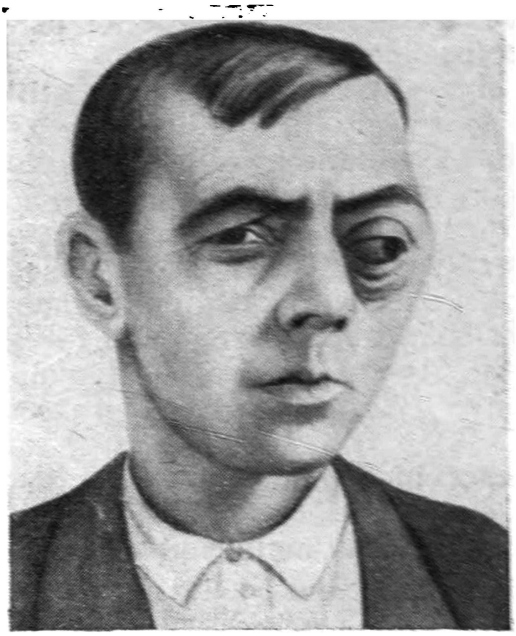


Fig. 58. Carcinoma invading the orbit from the maxillary sinus. Clinical signs: protrusion and displacement of the left eyeball and limitation of its mobility. The X-ray film showed slight shadowing of the left maxillary sinus and ethmoid labyrinth (I. I. Merkulov's report)

follows: the maxillary sinus 214, the frontal sinus 28, and the sphenoid sinus 27.

Similar statistics have been reported by other authors (I. Sendzyak, Y. N. Malyutin, A. I. Geshelin, D. I. Zimont, Denker, and others).

Malignant tumours of the paranasal sinuses are usually of primary origin. Cases of metastasis from some organ or a remote part of the body are rare exceptions. F. P. Mirzoyants, however, reported a case of metastasis of hypernephroid cancer into the antrum of Highmore, apparently through the postero-superior alveolar artery.

Among the 40 secondary orbital tumours studied by I. I. Merkulov the primary focus was most frequently found in the maxillary sinus (22 cases), the ethmoid labyrinth (10 cases) and the nasal cavity (8 cases).

The maxillary sinus. Carcinomata of the maxillary sinus usually derive from the mucous membrane. In the initial stage the patient may be quite unaware of the disease. As the tumour grows in size, however, it causes marked nasal obstruction which, according to some medical authors, is found in 70 per cent of the cases, and an unaccountable unilateral hemorrhage from the nose, which, however, is typical of sarcoma rather than carcinoma. The patient often complains of pus discharge from the nose since the process may have been complicated by a sinual empyema. As the tumour grows and invades the bony walls of the maxillary sinus the patient feels for a long time an unremitting, stubborn toothache. A. O. Vereshchinsky writes in this connection that "teeth are now filled, now extract-

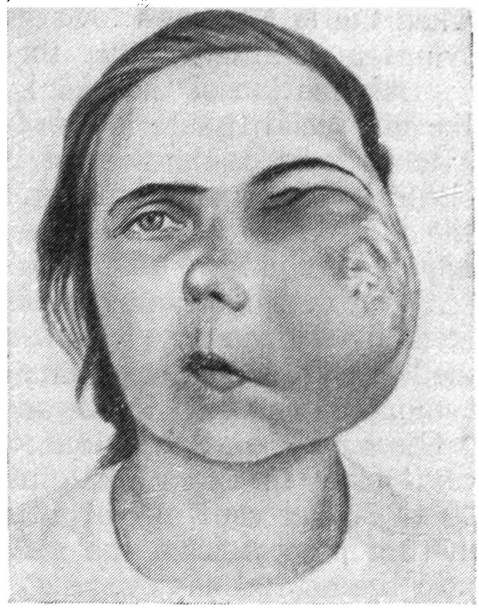


Fig. 59. Sarcoma of the maxilla (observation at the Leningrad Institute of Oncology)

ed—all without effect". When the newgrowth has penetrated into the sphenopalatine fossa the pain becomes particularly severe due to compression and invasion of the nerve trunks by the tumour. The second branch of the trigeminal nerve is the most liable to compression. Severe toothache is also felt when the tumour invades the alveolar process. A tumour developing in the floor of the maxillary sinus early destroys the soft tissue of the tooth socket and causes looseness of the teeth (Hattowska, 1959). In a number of cases D. I. Zimont also observed the following "dental" symptoms: toothache, swelling of the alveolar process, and sometimes of the cheek. The course of the process shows that "a seemingly innocent picture of a dental disease may conceal a malignant tumour in an early stage of development".

In far-advanced cases, where the tumour has pierced the bony walls of the sinus, there appear signs which sometimes not only permit to detect the tumour but even to identify its histological structure. Thus it has been established that a fast-growing sarcoma extends to the surface tissue, distorts the contours and upsets the symmetry of the face by straining, thinning down and damaging the anterior wall of the maxillary sinus and causing a swelling of the soft facial tissues, with dilatation of the cheek veins; a carcinoma, on the contrary, gradually grows towards the posterior wall of the sinus and tends to penetrate into the sphenopalatine fossa; trismus is also often observed.

Another distinctive symptom of sarcoma is "parchment crackling" on palpation of the anterior wall of the maxillary sinus, which is due to bone atrophy.

The consistency of sarcoma is softer than that of a cancer tumour; when the latter grows towards the facial wall the above-mentioned symptom is absent, since the wall breaks down rather early.

Deformation of the facial skeleton with subsequent changes in the soft facial tissues is also found when the malignant newgrowth extends towards the floor of the maxillary sinus, which causes the clinical symptom of a sunken hard palate. Tumour growth towards the alveolar process produces the swelling and protrusion of the upper gingiva.

The growth of a tumour towards the nasal cavity may be discovered by rhinoscopy, which reveals a marked prominence of the medial wall of the maxillary sinus towards the septum and even tumour-like masses in far-advanced cases.

Cases of maxillary sinus carcinoma growing into the orbital cavity are of exceptional interest to the ophthalmologist, since 40 to 50 per cent of all patients experience the extension of the morbid process from the maxillary sinus and ethmoid labyrinth into the orbital cavity.

One should not think, however, that this process takes place only in far-advanced extensive lesions of the paranasal sinuses, when the clinical picture of a malignant newgrowth is sufficiently clear as it is. Clinical studies have proved that ophthalmic symptoms may often be the initial signs of the disease.

In accordance with the current clinical classification of maxillary cancer into four periods, the penetration of the tumour into the orbit is usually ascribed to the third or fourth periods.

N. N. Petrov maintains that even an insignificant exophthalmos and diplopia indicate that the paranasal sinus neoplasm has grown into the orbital cavity. This view should be taken into account by ophthalmologists, rhinologists and roentgenologists in conducting a complex study.

Among the permanent signs of an orbital tumour are exophthalmos, lateral displacement of the eyeball and limitation of its mobility. I. I. Merkulov noted exophthalmos in all of his 42 patients with orbito-sinual malignant neoplasms.

These symptoms caused by changes of the position of the eyeball within the orbit are probably due to an increase of intraocular tension following the penetration of the tumour from the paranasal sinus into the orbital cavity.

Protrusion and displacement of the eyeball nearly always occur simultaneously. The extension of the tumour to the orbit, i.e., a secondary orbital tumour, causes, as a rule, lateral or oblique displacement of the eyeball to the side opposite the site of the neoplasm, and specifically: upwards when the tumour arises from the maxillary sinus, downwards when the tumour extends from the frontal sinus, and outwards when the tumour originates in the ethmoid labyrinth. Primary orbital newgrowths developing in the muscular

funnel at the top of the orbital fossa usually produce direct exophthalmos, i.e., protrusion of the eyeball along the orbital axis, without any lateral displacement.

Exophthalmos caused by pressure by the tumour is stubborn and persists even when pressure is applied to the eyeball from the outside. An obstacle to reposition by pressure on the eyeball is, according to I. I. Merkulov, a sign of a malignant neoplasm inside the orbit.

The penetration of the tumour from a paranasal sinus into the orbit rarely fails to cause exophthalmos; the reason is the small size of the neoplasm, or its location anteriorly to the equator of the eye, or else the location of the tumour in the deeper layers of the muscular funnel.

In the majority of the cases exophthalmos and displacement of the eyeball are combined with a limitation of its mobility. In the presence of a tumour developing from the maxillary sinus the mobility of the eyeball is limited downwardly, i.e., in the direction of the primary focus. Most commonly the tumour simply prevents the movement of the eyeball towards itself.

Diplopia caused by a limitation of eyeball mobility rarely accompanies secondary orbital tumours.

Tumours of the orbito-sinual region may, by putting pressure on the lateral surface of the eyeball, produce a change in its form and spherical configuration, which, naturally, has an adverse effect on refraction.

According to I. I. Merkulov, a secondary orbital tumour may be attended with elongation of the optic axis and a change in the curvature of the corneal surface, sometimes in only one meridian, which in turn frequently causes intensified refraction or astigmatism.

Another sign indicating the extension of the tumour from the paranasal sinus into the orbit is increased ocular tension.

The optic functions remain intact in most cases of tumours of the maxillo-orbital region.

The growth of the tumour into the orbital cavity is sometimes attended with excessive lacrimation.

The ethmoid labyrinth. The most favourite initial site of a malignant tumour are the posterior ethmoid cells.

An enlargement of these cells primarily causes an obstruction of the nasal cavity with difficulty of nasal respiration as well as impairment of the olfactory function, and even complete anosmia, which may be due not only to nasal obstruction but also to damage of the roots and endings of the olfactory nerve. In addition, newgrowths of the ethmoid labyrinth are often accompanied by nasal hemorrhage.

The malignant tumour of the labyrinth grows not only towards the nasal cavity but also outwards, which is liable to produce

nasal deformity and swelling at the supero-internal angle of the orbit.

Nor should the ophthalmologist disregard the danger of a labyrinthine tumour extending to the orbit from the middle and anterior ethmoid cells through the lacrimal bone and papyraceous lamina.

The ophthalmic symptoms of an orbito-ethmoidal newgrowth are outward and forward exophthalmos, outward displacement of the eyeball and limitation of its inward movements. Tumours in this region produce not only mechanical limitation of eyeball mobility; paresis and paralysis of the internal rectus and obliquus muscles and the oculo-motor nerve occur fairly often, too.

Tumours originating in the posterior cells of the ethmoid labyrinth deserve special attention. I. I. Merkulov laid particular emphasis on the dissociation of ophthalmic symptoms attendant upon them, even when the process was in an early stage. This dissociation consists in substantial disorders in the optic functions with a marked loss of vision and central scotoma found with a slight exophthalmos and minor changes of the ocular fundus in the optic disc region, such as paleness, choked disc, and unmarked retinal edema, or even with a normal ocular fundus.

I. I. Merkulov noted in his studies that half of the patients with orbito-sinual tumours arising from the posterior ethmoid cells had a marked loss of vision and limitation of the field of vision in the other eye as well, i.e., on the side opposite the location of the orbital tumour. An irregular concentric narrowing of the field of vision was also observed, though less frequently. Eleven out of forty two patients had developed central scotoma.

Neoplasms in the posterior ethmoid cells and extension of the tumour to the orbit often give rise to excruciating neuralgic headaches coming on at dusk and nighttime in consequence of the pressure of the tumour on the nerve trunks passing through the fissura orbitalis superior. Lesions of the nerves, mainly the n. oculomotorius, owing to their compression by the tumour growing from the posterior ethmoid cells into the orbit and the fissura orbitalis superior may produce the supraorbital fissure syndrome, which consists of ptosis, often with exophthalmos, full or partial ophthalmoplegia, and anesthesia of the cornea. Full ophthalmoplegia involves the affection not only of the external muscles, such as the rectus, obliquus and levator palpebrae superioris, but also of the internal muscles—the retinal sphincter and the ciliary muscle. Partial ophthalmoplegia may be manifested in a paralysis of the external and internal muscles.

To sum up, the symptomatology of marked ophthalmoplegia consists of ptosis, i.e., drooping of the upper eyelid, and immobility of the eyeball; in ophthalmoplegia interna the pupil is dilated and reacts neither to light nor to convergence. Accommo-

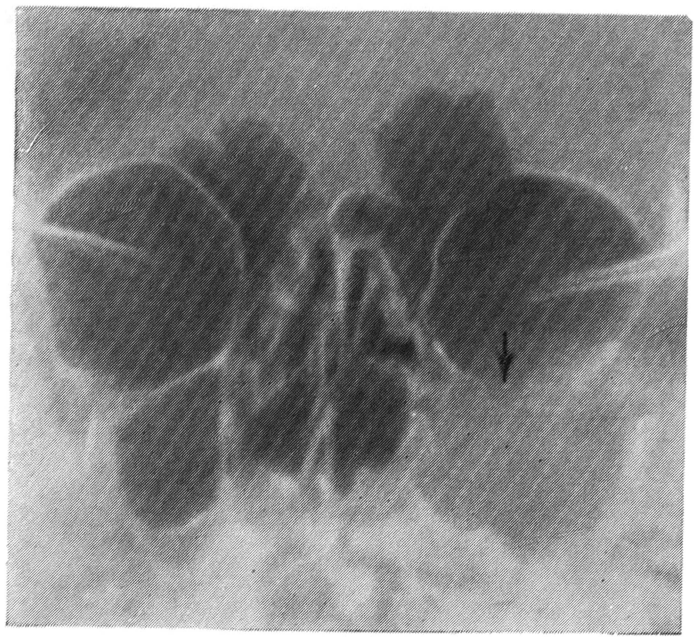


Fig. 60. Carcinoma of the left superior maxillary bone. The left maxillary sinus is seen as a structureless shadow; destruction of the orbital floor is indicated by an arrow (V. G. Ginsburg's report)

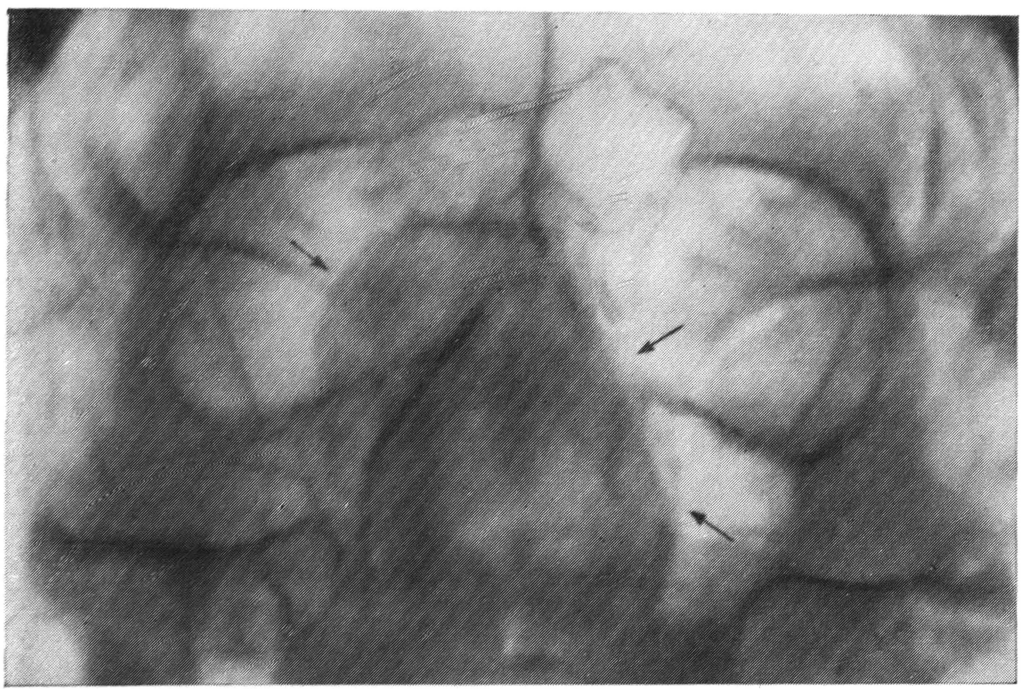


Fig. 61. Nasopharyngeal tumour invading the sphenoid sinus and the ethmoid labyrinth. The tumour shadow is distinctly differentiated (see arrows). Clinical signs: exophthalmos and slight outward displacement of the eyeball. The ocular fundus is normal (M. M. Baltin's report)

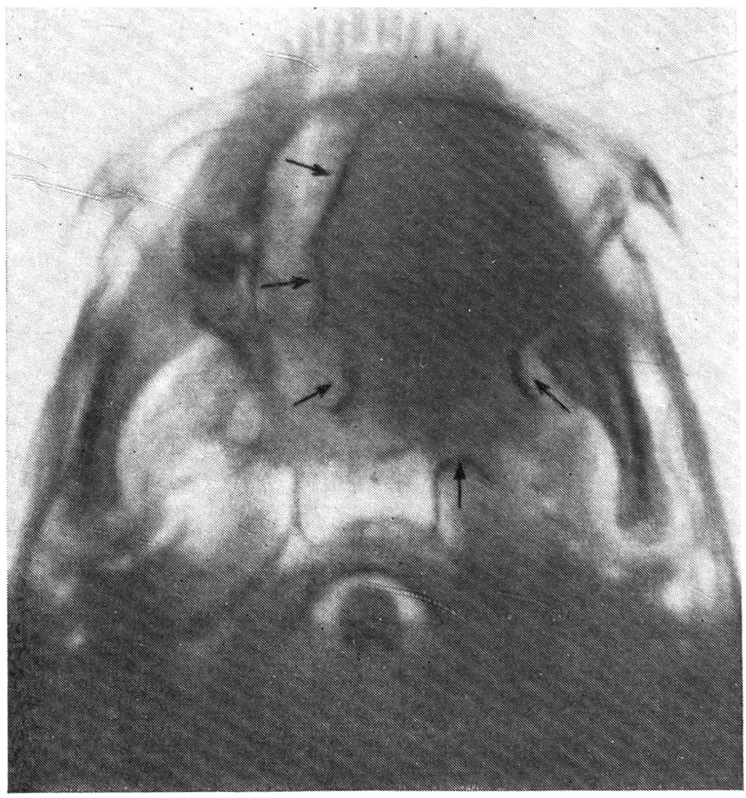


Fig. 62. The same case as in Fig. 61. Axial projection. The tumour shadow is clearly differentiable as occupying the region of the sphenoid sinus and the ethmoid labyrinth at right

dation is also partially impaired in consequence of ciliary muscle paralysis; a bilateral affection causes the so-called Hutchinson's facies. Apart from changes in the optic functions orbito-ethmoidal tumours are often accompanied by disorders in the lacrimal passages.

Isolated malignant tumours of the *sphenoid sinus* are encountered but rarely. In the majority of cases this sinus becomes involved in the process secondarily, i.e., by extension of the tumour from the posterior ethmoid cells. Therefore, the clinical and ophthalmic signs of the neoplasm invading the orbit are almost identical to those accompanying tumours which penetrate into the orbit from the posterior ethmoid cells; specifically these are: substantial disorders in the optic nerve, its atrophy with marked loss of vision and subsequent amaurosis, complete or partial ophthalmoplegia, all appearing even before the onset of exophthalmos.

Attacks of neuralgic headache in the region of the temporal and sincipital regions come on at a later period.

A malignant tumour in the *frontal sinus* is an exceptionally rare phenomenon. A primary cancer of this sinus has been reported in Russian literature by A. M. Gelfon, A. I. Geshelin and others, and sarcoma—by B. L. Frantsuzov and N. D. Danilov.

In the early stages of the malignant process the symptoms are moderate headaches, later joined by symptoms caused by protrusion of the walls of the sinus under pressure from a tumour lodged within it, the orbital wall being the first to be pressed downwards. The ophthalmological signs evident even before the tumour has penetrated into the orbit are those of palpebral edema, exophthalmos and eyeball displacement down- and outwards. Changes in the refractive media and optic nerve are nearly always absent. Newgrowths in the frontal sinuses rarely produce metastases.

Course and prognosis. The development of malignant tumours of the paranasal sinuses comprises the latent period, which is divided into the first and second stages, and the active period.

The latent period may last rather long, up to 3 or 4 years, whereas the active period is marked by a rapid progress of the disease which never lasts more than a few months.

The insidious course of the disease in the latent period is due to the fact that the tumour fails to fill the entire sinus and therefore does not exert a noticeable pressure on its bony walls and nerve trunks. This absence or meagreness of symptoms in the first latent stage of the disease accounts for the belated application of the sufferer for medical aid. By way of illustration we can adduce the evidence of D. I. Zimont. Out of 37 patients with malignant neoplasms in the nose and nasopharynx 22 applied for medical assistance when surgical treatment was already impossible; L. I. Sverzhevsky's evidence is to the same effect.

The pace of growth of the tumour, the length of the latent period and the speed of progress in the active stage depend on the general resistance of the body, primarily on the neuro-psychic state of the patient.

The prognosis and the related problem of the duration of the first latent stage are contingent on a number of factors, such as the character of the histological structure of the newgrowth, the primary focus, direction of tumour growth, and, finally, the age of the process.

The following data are given as an illustration.

1. Round-celled and micro-cellular sarcomata run a more malignant course than large-celled sarcomata.
2. Polymorphocellular sarcomata are marked by a severe course with exophthalmos caused by extension of the tumour into the orbit at a very early date.
3. Round-celled sarcomata in one- and two-year-old children grow so fast as to become a far-advanced, diffuse process in one or two months' time.
4. Pigmentary sarcomata and melanosarcomata are especially malignant.
5. Malignancy and rapid growth are also characteristic of those cancerous neoplasms which histologically are found to contain a large number of karyokinetic figures, with marked cellular atypia and tumour cells within the vessels.

The outlook for a malignant newgrowth of the paranasal sinus, particularly one penetrating into the orbit, is very grave. The patient, if untreated, does not live longer than two years. Cancerous newgrowths run a particularly severe and rapid course, whereas in sarcoma the prognosis is more hopeful. As to the relation of prognostication to tumour location, it should be noted that malignant newgrowths originating in the posterior ethmoid cells and the sphenoid sinus may be so dangerous as to make the prognosis well nigh hopeless.

Diagnosis. It is highly important to detect the malignant newgrowth at an early stage, where it can still be checked. In the presence of a secondary orbital tumour early diagnosis is simply a conventional term implying the identification of tumours which have not yet produced a facial deformity and whose growth can bereversed.

The only symptom of such orbito-sinual tumours is a stubborn unaccountable toothache or pain in the anterior wall of the maxillary sinus, as well as exophthalmos. It should be recalled that, as is stated by N. N. Petrov, even an insignificant exophthalmos and diplopia are signs of tumour ingrowth into the orbit. He also notes that ophthalmic symptoms often appear in advance of those in the paranasal sinus from which the tumour takes its origin. If a slight exophthalmos is concurrent with paralysis of the ocular

muscles or attended with a large loss of vision and unilateral central scotoma, and even in the latter's absence, there is reason to suspect a malignant tumour that has penetrated into the orbit from the paranasal sinuses or from the cranial cavity through the supraorbital fissure, although the ocular fundus may not appear to be pathologically changed.

Newgrowths transgressing the limits of a paranasal sinuses and distorting the facial contours, with a unilateral swelling of the cheek, gingiva, hard palate, etc., are easy to identify.

Palpation of the swollen area aids the diagnosis. It is known that sarcoma is composed of dense and elastic tissue, and osteoma of dense but indurated tissue; the hydatid cyst and mucocele have a fluctuating tumour; with a dental cyst the anterior wall of the maxillary sinus is perfectly smooth, while with a malignant tumour it is tuberous.

The instrumental method of nasal examination, namely, anterior, middle and posterior rhinoscopy, is very important for the identification of tumours penetrating into the nasal cavity, since it sometimes permits to detect the tumour, determine its size, the colour of the mucosa, and the presence of disintegration.

The most favourite sites of malignant tumours of the nasal cavity are the anterior portion of the nasal septum, particularly for sarcoma, the anterior ends of the nasal turbinates and the middle nasal meatus, as well as the olfactory region, i.e., the upper and supero-posterior portions of the nose. The malignancy of the process is to a certain extent indicated by the following signs: knobby granulations or small swellings of variable colour, each colour being characteristic of a particular type of tumour, for instance, bright-red—of cancer, pale-pink—of spindle-celled carcinoma, the colour of meat—of round-celled sarcoma, green—of chloroma, and deep-red—of melanosarcoma. A good reason for suspicion is also provided by hemorrhage, spontaneous or touched off with a probe, particularly in the case of a highly vascularised sarcoma, as well as by polyps relapsing after their careful removal.

Final decision on the character of the changes discovered is possible only after biopsy, which, however, may also involve difficulties in differentiating between malignant and benign newgrowths, as well as between syphilitic and tuberculous granulomas.

The X-ray methods of diagnosis, namely, common skiagraphy, contrast roentgenography, tomography, etc., are acquiring special importance for identifying newgrowths in the nose and paranasal sinuses. These methods may help distinguish between malignant and benign tumours. The latter are characterised by a gradual distention of the paranasal sinus owing to pressure on its walls. A malignant tumour which grows by infiltration destroys the walls of the sinus, and if it grows in the direction of the orbit the dividing wall breaks down and the tumour penetrates into the orbit.

In an early stage of the disease, however, the X-ray film shows only a shadowing of the paranasal sinus and swelling of its mucous membrane. In such cases Hattowska recommends a cytological examination of the sinus contents, which are withdrawn by puncture.

The diagnostic value of the cytological examination of the sinual contents for identifying malignant tumours of the nose and paranasal sinuses was discussed inter alia at the 5th U.S.S.R. Congress of Otorhinolaryngologists in 1958 in the reports made by D. I. Zimont and M. K. Faizullin. The data of cytological examination for lesions of the maxillary sinus proved valid in nine out of every ten cases.

In a later stage of malignant growth the X-ray film may show a damage to the walls of the paranasal sinus. Hattowska attributes great importance to the fact of destruction of the posterior and superoposterior portions of the maxillary sinus; she recommends a study of these portions by X-rays in all cases when the cause of pain is obscure.

X-ray examination sometimes permits to find out whether the tumour has developed from the paranasal sinus or from the orbit. If the tumour has not yet destroyed the wall bordering on the orbit one should examine the X-ray film for the direction in which the remnants of the wall have been pushed. This will allow a correct conclusion regarding the direction of tumour growth. For example, the displacement of the wall towards the orbit may indicate that the tumour grows from the paranasal sinus, whereas distention of the orbital cavity is evidence of its being the initial site of the tumour.

Figs. 60, 61 and 62 show X-ray pictures of malignant tumours.

The most pathognomonic symptoms of a paranasal sinus tumour penetrating into the orbit are, as has been noted above, exophthalmos and displacement of the eyeball. These signs, however, are also found in other diseases, for instance, in orbital inflammations of any etiology: phlegmons, retrobulbar and subperiosteal abscesses, orbital periostitis, as well as in cases of cystoid formations, etc.

Anamnesis helps differentiate a tumour from an inflammation: in inflammatory processes exophthalmos develops early, in one or two days, in fact, whereas with malignant newgrowths, even if rapidly growing, exophthalmos appears after weeks and even months.

Difficulties in diagnosis may arise also when the blastomatous process assumes an acute character, such as sarcoma in children, or is accompanied by an orbital phlegmon, as in the case of primary cancer of the frontal sinus observed by A. M. Gelfon, or else when the inflammatory process in the orbit has taken a torpid course. One of S. S. Golovin's papers contains a report on a female patient with orbital sarcoma, identified as a sluggish orbital phlegmon,

which shows how difficult it may sometimes be to avoid this diagnostic error.

Malignant tumours of the orbit have a number of signs akin to orbital periostitis; it should be borne in mind in this connection that changes in the orbital periosteum may come not only by extension of the inflammatory process from the paranasal sinus, but also in the wake of specific changes provoked by tuberculosis, syphilis, etc. Apart from exophthalmos, which is often present in periostites of various etiology, confusion of these forms with malignant tumours is caused by such signs, common to both processes, as disintegration of tissue, fetid pus discharge, etc.

There is least difficulty in ruling out tuberculous periostitis, since this disease is nearly always attended with fistulas leading into the orbit or scars in its external portion, i.e., in parts unconnected with the paranasal sinuses, whereas rhinogenous secondary tumours of the orbit are located in its upper, inner or lower portions. Moreover, orbital tumours never involve scarring, while fistulas are among their rarest symptoms.

So far as luetic periostitis is concerned, it can be confused with a secondary rhinogenous tumour of the orbit only if both processes are confined either to the orbital roof, near its entrance, or to the supraorbital fissure. Such clinical symptoms as nocturnal pain in the focus area, in the depth of the orbit, paresis and paralysis of the orbital nerves and muscles, particularly in the so-called supraorbital fissure syndrome, and optic neuritis, are found not only with syphilitic periostitis, but also with malignant tumours of the paranasal sinuses penetrating into the orbit through the fissura orbitalis superior. Diagnosis is substantially aided by Wassermann's test and X-ray examination of the paranasal sinuses and the orbit.

The suspicion that the disease is of syphilitic nature may be easily disproved by the fact that orbital syphilis is, as a rule, a primary process without any relation to changes in the paranasal sinuses. It is more difficult to identify the gummas located at the internal surface of the lower orbital boundary, near the lacrimal sac, which is their favourite site; since they produce no signs of inflammation, they may well be mistaken for tumours.

Apart from a general examination of the patient and biopsy, X-ray study of the orbito-sinual region is mandatory for a final judgement on the innocence or malignancy of the process. X-ray diagnosis is based on the fact that a malignant process involves bone defects of complete resorption of the sinus walls, seen in the film as an intense homogeneous and structureless shadow, which reveals in this way changes in the very structure of the bony walls of the sinus, whereas a benign process, particularly in an early stage, produces ectasia of the sinus walls without mechanical damage.

Conjecturing upon the character of a secondary malignant newgrowth in the orbito-sinual region, one should first of all search for cancer, which is very likely to arise in this place.

The X-ray study should be undertaken in three mutually perpendicular projections, yet the most valuable are the axial pictures and tomograms made in the naso-frontal section, since they permit to detect "breaks" in the bony walls of the maxillary sinus, specifically in the anterior wall as the most liable to destruction.

In certain cases X-ray examination may help differentiate between carcinoma and sarcoma. According to data furnished by M. K. Faizullin, the difference between sarcoma of the paranasal sinus and cancerous tumours consists in that the zone of sarcomatous tumours is found to contain additional shadow inclusions produced by bony elements. In addition, bone destruction in sarcoma may be discovered even when the sinus pneumatisation is still retained; once started, destruction proceeds much faster than in cancer and extends to the adjacent regions of the facial skeleton.

A protrusion in the anterior wall of the maxillary sinus is symptomatic not only of a tumour but also of *a dental cyst*. A common sign of both is, apart from distention of the sinus, fluctuation and sometimes parchment-crackling in consequence of atrophy of the anterior sinus wall. Palpation is the basic means of distinguishing these forms; with a dental cyst the anterior wall is smooth and the facial surface perfectly intact, whereas malignant tumours of the maxillary sinus cause deformation of the facial skeleton and tuberosity of the anterior wall of the sinus. The diagnosis is often verified by additional methods, such as puncture of the sinus, X-ray examination, etc. In obscure cases the diagnosis is made certain only at operation.

A newgrowth has sometimes to be differentiated from a closed *empyema* which may complicate the course of the basic tumour process. Besides puncture of the sinus and X-ray examination the diagnosis rests on X-ray study of the sinus filled with a contrast medium.

In certain cases tumours of the orbito-sinual region may be mistaken for cystoid formations growing from the paranasal sinuses, chiefly for mucocele. These diseases are apt to produce both exophthalmos and eyeball displacement. The most convincing roentgenological sign of mucocele is distention of the paranasal sinus, whereas malignant tumours produce in the film an erosion of the bony walls of varying degree. The differential diagnosis between a dental cyst bulging the anterior wall of the maxillary sinus and a malignant tumour is based on the fact that the former produces a uniform smooth surface in the swollen area, as well as parchment-crackling and fluctuation, the facial cover tissues remaining normal. Diagnosis is nevertheless suspended until after an X-ray examination and puncture of the maxillary sinus.

Finally, it should be remembered that foreign bodies of the paranasal sinus may present a clinical picture bearing much resemblance to that of a malignant tumour; this refers to cases of foreign bodies causing paranasal sinus empyemas. The possibility of such confusion is noted by S. S. Golovin, who once discovered a wooden splinter in his patient in an attempt to extract a tumour.

Treatment. The basic types of treatment of malignant newgrowths in the nasal cavity and paranasal sinuses are surgery and radiotherapy with X-rays and radium. Since radiation treatment is effective only for sarcomatous tumours, combined treatment is regarded as the most helpful today, radiotherapy being either a preliminary or an accessory method of treatment following an operation; in certain cases it is used both in the pre- and postoperative periods.

Hölmgren has since 1922 effectively used electrocoagulation with introduction of radium into the operative wound. He conducts a preoperative X-ray irradiation of the operative field and, following the operation, of the regional lymph glands. After more than ten years of experience with 200 patients he has come to regard coagulation as the basic procedure and assigns radiation treatment only a secondary role.

Since the principal aim of the treatment of malignant newgrowths is their complete extirpation, exclusively external operations are employed, often in combination with electrocoagulation. Endonasal operations are indicated when the tumour is confined to a small portion of the nasal cavity and can be completely extracted through the nose.

For orbito-sinual tumours extending from the paranasal sinus to the orbit the following surgical methods are primarily indicated: combined exenteration of the orbit and adjacent sinuses after S. S. Golovin; extra-orbital exenteration of the orbit and paranasal sinuses after V. P. Filatov and N. K. Lysenkov; transorbital method suggested by N. N. Bogoslovsky; B. A. Schwartz's method; and operations after Denker and Moore (see Chapter VII).

Surgical treatment of the orbito-sinual region is sometimes effected not only by removal of the principal morbid focus in the sinus or orbit, but also by extraction of the affected regional lymph glands; the latter may also be eliminated by means of radium or X-ray therapy. In I. I. Merkulov's opinion, the treatment of secondary orbital tumours is generally almost ineffective.

VI

Lacrimal Disorders Associated with Nasal and Paranasal Sinus Diseases

As is known, both parts of the lacrimal apparatus—the one that secretes and the one that conveys tears—are functionally integrated. That is why in discussing the pathology of lacrimal passages one should touch upon some aspects of tear secretion, particularly on its susceptibility to pathological processes occurring in the nose and paranasal sinuses.

REFLEX LACRIMATION

Reflex lacrimation is caused by hypersecretion of the lacrimal gland.

A description of the reflex arc which transmits stimulation from the nose to the lacrimal organs via the trigeminal nerve was given in Chapter I.

As to the frequency of reflex disorders of tear conveyance, according to P. Y. Tikhomirov they account for 10 per cent of the total cases of abnormal lacrimation. The causes of this disturbance are sometimes unidentifiable.

It should be noted that reflex lacrimation in pure form is infrequent. In the majority of cases, hypersecretion is concomitant with disorders in tear conveyance; that is to say, in clinical practice the combined form of lacrimation is the most common.

Reflex lacrimation is found in various diseases of the eye, such as keratitis, iritis, cyclitis, blepharitis, etc. There is also evidence of its being encountered in refraction anomalies, such as astigmatism and hypermetropia.

As to the question of reflex lacrimation caused by certain changes in the nose, attention should be first of all turned to the two reflexogenic zones in the nose (after Killian): (1) the tuberculum septi—a portion of the nasal septum lying anteriorly to and somewhat

below the middle nasal turbinate, and (2) the anterior end of the inferior nasal turbinate.

Thus, the cause of reflex lacrimation may be irritation of the mucous reflexogenic zone, of a hypertrophied middle turbinate, for instance, or of a deviated nasal septum with spurs.

Reflex lacrimation of rhinogenous origin is also encountered in acute coryza, irritation of the nasal mucosa, as with liquid ammonia or inhalation of tobacco smoke, etc., as well as in chronic pathological processes within the nose. Disturbed blood circulation in the paranasal sinuses, pain reflexes emanating from them, and irritation of the nasal mucosa by a paranasal sinus discharge also provoke intensified tear secretion.

Adenoids also cause reflex hypersecretion in the lacrimal glands.

It should be noted that lacrimation in acute coryza and a number of other diseases may be associated with the swelling of the cavernous tissue of the nasolacrimal duct mucosa.

F. S. Bockstein attaches great importance to the reflex stimulation of hypersecretion on the assumption that even in cases of mechanical pressure on the nasolacrimal duct it is not the pressure itself but the resultant irritation that matters.

ETIOLOGY AND PATHOGENESIS

As noted in Chapter I, the lacrimal passages begin from the lacrimal puncta, falling directly into the lacrimal canaliculi, and ending at the nasal outlet of the nasolacrimal duct under the inferior nasal turbinate. A disorder of tear drainage into the nose may be caused by an obstacle to tear conveyance in any portion of this tract. According to P. Y. Tikhomirov, lacrimation, contrary to the common opinion, is most frequently caused by various disturbances in the initial portion of the lacrimal passages (lacrimal punctum, lacrimal canaliculi) rather than in the inferior portion (nasolacrimal duct).

Pathology of lacrimal puncta is a frequent cause of various disorders in tear conveyance, which is disturbed by their narrowing or obliteration; another cause of lacrimation is eversion of the lacrimal punctum (eversio puncti lacrimalis), when instead of being submerged in the lacrimal lake it is turned somewhat anteriorly, whereas normally it should be facing backwards, towards the eyeball and cannot be seen until the eyelid is elevated. This condition is found with chronic ulcerating blepharitis, chronic lesions of the conjunctiva, cicatricial eversions of the eyelids, paralysis of the facial nerve, senile drooping of the eyelids, etc. Lacrimation caused directly by the lower eyelid being detached from the eyeball may also be found in young subjects with a high nasal bridge and protruding supraorbital boundary, which is known as the "eagle's gaze" syndrome described by N. Y. Pokhisov.

In the records of the Helmholtz Institute of Ophthalmology, as reported by P. Y. Tikhomirov, eversion of the inferior lacrimal punctum with a slight drooping of the lower eyelid margin is the most frequent (49 per cent) cause of lacrimation.

Disorders of tear conveyance in the lacrimal canaliculi may be organic and functional.

Organic affections of the lacrimal canaliculi refer to their congenital atresias and splitting, cicatricial narrowing and even complete imperforation caused by trachoma, concretions, fungi and inflammations. Stricture of a lacrimal canaliculus as a cause of lacrimation accounts, as evidenced by P. Y. Tikhomirov's studies, for 11 per cent of his cases of lacrimation.

Functional disorders are of no small importance either, since the major factor of lacrimation is the pumping activity of the lacrimal canaliculi, which are set into action by compression and expansion of their lumina during winking.

In disorders of the above-mentioned kinds all the portions of the lacrimal passages, in particular the canaliculi with no crude anatomical dislocations, are perfectly patent and their passive patency is quite normal, i.e., in irrigation of the lacrimal passages through the canaliculi the liquid freely passes into the nose. Among other causes, functional disorders are apparently joined by a disorder in the elasticity of the canaliculus walls or a weakening of their muscular apparatus.

Disorders of tear conveyance caused by pathology of the lacrimal sac and nasolacrimal duct and leading to dacryocystitis deserve special attention of ophthalmologists and rhinologists alike. This particularly concerns dacryocystitis of rhinogenous etiology developing as a result of stagnation of lacrimal secretion within the nasolacrimal duct and lacrimal sac, which is caused by obstruction of the duct's nasal outlet.

It should be kept in mind, however, that since the nasolacrimal duct, which is directly continuous with the lacrimal sac, is in effect its extension, both formations should be anatomically and clinically regarded as a whole, i.e., as a vertical knee of the lacrimal passages. To this concept we adhere below.

Indeed, each inflammatory disease of the nasolacrimal duct leads to stagnation of lacrimal secretion within it and may ultimately cause a disease of the lacrimal sac; and conversely, diseases of the lacrimal sac are often concomitant with an affection (imperforation) of the nasolacrimal duct. Thus, the term "dacryocystitis" implies an acute or chronic disease not only of the lacrimal sac proper, as is inferred from its name, but also of the nasolacrimal duct.

According to P. Y. Tikhomirov, stricture of the nasolacrimal duct is nearly always associated with diseases of the nasal cavity, whereas the latter diseases rarely serve to produce lacrimation, which depends on changes in the upper portions of the lacrimal passages.

The incidence of rhinogenous dacryocystitis, according to the summary data of the E. N. T. Clinic at Moscow Second Medical Institute collected by F. S. Bockstein in a study of 437 cases of various marked affections of the nasal cavity, is 3.6 per cent. In relation to the total cases of lacrimation, however, those caused by a disease of the nasolacrimal duct account for 11 per cent (P. Y. Tikhomirov).

Rhinogenous obstruction of the nasolacrimal duct may arise in two ways: (1) by mechanical compression of the duct; and (2) by extension of the pathological process from the nasal cavity and paranasal sinuses to the lacrimal passages.

1. *Disorders in the patency of the nasolacrimal duct caused by its mechanical compression.* Such disorders are seen in a variety of pathological conditions of the nasal cavity, namely, with traumas (including those made at operation), hypertrophy of the nasal turbinates and empyemas of the ethmoid labyrinth, tumours, marked deviations of the nasal septum, as well as with narrowing of the lumen of the nasolacrimal duct over a considerable length (7 to 8 mm) in consequence of periosteal swelling of the duct wall.

Injuries to the nasal bones in gunshot wounds often lead to obstruction of the duct and even to dacryocystitis, lacrimation and other symptoms becoming apparent only within a few months of the trauma.

In his monograph entitled *Surgery of the Lacrimal Passages*, F. S. Bockstein reports a number of nasal traumas which produced dacryocystitis with ectasis and fistula of the lacrimal sac and its complete stenosis at the site of its communication with the duct. Numerous similar reports by other authors are available.

The obstruction of the nasolacrimal duct following a trauma sustained in surgical interference may take place after the following operations: puncture of the maxillary sinus through the middle and inferior nasal meatus, curettage of the medial wall of the maxillary sinus (Caldwell-Luc's operation), exposure of the maxillary sinus after Denker in the absence of the prelacrimal bay, removal of the facial wall in close proximity to the incisura piriformis, when a considerable portion of the medial wall of the inferior nasal meatus has to be resected for a malignant tumour. Considerable injuries may be inflicted in the surgical treatment of ozena after Halle's method whereby the lateral wall of the nose is mobilised. In view of this many surgeons, when opening the maxillary sinus, resect only the lower portion of the lateral wall of the inferior nasal meatus.

The nasolacrimal duct may be injured and become obstructed during opening of the frontal sinus (in resection of part of the frontal process and lacrimal bone) and the ethmoid labyrinth.

Notwithstanding these indubitable clinical facts, some surgeons with a wide experience to their credit, such as L. T. Levin, F. S. Bockstein, D. M. Rutenburg, and others, emphasise that stubborn and

prolonged disorders in the lacrimal passages are nevertheless rarely encountered, which gives reason to regard them as being fairly resistant to injuries.

Narrowing of the lumen of the nasolacrimal duct most frequently begins at the lower portion, at the entrance to the nasal outlet; cases have been observed, however, when it had started at the site of communication between the lacrimal sac and the nasolacrimal duct, i.e., in the upper portion.

In view of this and drawing on an X-ray study of the pathology of the lacrimal passages, S. A. Dering distinguishes two types of chronic dacryocystitis: *the ectatic* and *the stenosing*. In the former the inflammatory process followed by scarring develops by ascension; the stricture of the lower portion causes permanent stagnation in the lacrimal sac and its gradual distention. In stenosing dacryocystitis, however, the inflammatory process extends from the top of the lacrimal sac downwards. Drainage from the sac is at first free. The inflamed lacrimal sac becomes cicatricial and shrunken and then completely obliterated. The etiology and pathogenesis of this type of dacryocystitis are uncertain.

The upper portion of the duct may become imperforated under pressure from an empyema of the ethmoid labyrinth through the thin lacrimal bone and from a deviated nasal septum (stenosing type of dacryocystitis). In the inferior portion, however, stenosis is not infrequently caused by the hypertrophied inferior turbinate being pressed against the lateral nasal wall and by the resulting closure of the nasal outlet. In certain cases closure of the outlet may be due to the inferior nasal turbinate being pressed against the lateral nasal wall by a deviated nasal septum with a spur (ectatic type of dacryocystitis).

Tumours, polyps and cysts in the maxillary sinus may also cause compression of the nasolacrimal duct.

2. *Obstruction of the nasolacrimal duct caused by an inflammation extending from the nasal cavity.* In spite of a number of predisposing factors contributing to the direct extension of the infectious process from the nose to the nasolacrimal duct (see below), the latter's specific changes in such diseases as tuberculosis, lupus, syphilis and scleroma are exceptionally rare.

In these diseases dacryocystitis has nearly always a secondary non-specific character, and is caused by obstruction of the duct lumen either at the nasal outlet or in the higher portions. In other words, the mechanism of its development is identical to that of dacryocystitis of another etiology. Thus, according to Elliot (quoted from Stock), histological examination of 310 extracted lacrimal sacs revealed no tuberculous changes in any. Similar evidence exists in relation to syphilis and scleroma.

A. I. Maslennikov, V. I. Voyachek, Ritter and others have given much attention to atrophic processes in the nose, particularly ozena,

when considering the etiology of dacryocystitis. The reason is the detection of dacryocystitis in many sufferers from such affections. Ritter presumed that in this disease atrophic expansion of the duct outlet and its mechanical obstruction with crusts were the predisposing causes for the infection to spread by contact from the nose to the nasolacrimal duct.

According to evidence by other specialists, however, the high rate of dacryocystitis in patients with ozena is by no means a rule. For example, L. I. Sverzhevsky discovered dacryocystitis in only 8 out of 116 cases of ozena, F. S. Bockstein in 6 out of 115 and D. M. Rutenburg in 16 out of 324 (5 per cent).

One cannot but agree with F. S. Bockstein's view that although ozena and the atrophy of the nasal mucosa do play a certain role in the etiology of dacryocystitis, "there is no reason whatever to regard them as a major factor in this respect". As will be shown below, tuberculosis, syphilis, and rhinoscleroma have a minor role to play in the pathogenesis of dacryocystitis.

There is a number of reports in literature on cases where pus in the maxillary sinus had broken into the lacrimal sac through the orbital wall and caused its phlegmonous inflammation followed by a fistula at the inner angle of the orbit (Hajek, Rhese, Treitel; quoted from S. M. Burak).

Contrary to Kuhnt's assertions to the effect that the maxillary sinus and particularly the ethmoid labyrinth are considerably involved in the pathogenesis of dacryocystitis (in the latter case by formation of a pyosaccus as a result of destruction of the thin bony wall separating the sac from the ethmoid labyrinth), as well as to the above-cited reports, F. S. Bockstein discovered affected lacrimal passages in only 4 out of 143 cases of plainly chronic diseases of the paranasal sinuses, while among the 203 patients he had operated upon for dacryocystitis only 6 (3 per cent) had a diseased ethmoid labyrinth and 2 (1 per cent) had a maxillary sinus disease.

The evidence of F. S. Bockstein and a number of other clinicians, such as L. I. Sverzhevsky, M. I. Averbach, West, Ritter, and others, shows that the role of the paranasal sinuses in the genesis of dacryocystitis is likewise unimportant.

A special place belongs to *dacryocystitis occurring in the newborn*, where it is due to congenital atresia of the nasal duct outlet (blind end). This disease should be more properly classed among developmental defects. As noted in Chapter I such congenital defects are found in 35 per cent of the newborn. In exceptional cases a newborn may develop dacryocystitis following an injury to the skull and nasal duct during labour in the case of a narrow maternal pelvis or the application of forceps, as well as in congenital syphilis and tuberculosis.

As has been shown by special anatomo-histological examination of the newborn made by F. Y. Mogilevskaya of the Helmholtz

Institute of Ophthalmology at the Chair of Normal Anatomy of the Moscow First Medical Institute, a bled-like prominence of thin connective-tissue membrane facing the middle line or the floor of the nasal cavity was noted in a number of cases in lieu of a gaping or fissural opening of the nasolacrimal duct outlet.

Among the etiological factors of dacryocystitis in the newborn there may be folds and diverticula in the lumen of the nasolacrimal duct, which cause a gelatinous plug to form within it, as well as a swelling of the nasal mucosa at the nasal duct outlet, its compression with the inferior nasal turbinate, and true stenosis as a result of defective rudimentation of the teeth.

The predisposing causes of rhinogenous dacryocystitis in adults are as follows:

(a) Direct extension of the epithelium of the nasal mucosa to the mucous membrane of the nasolacrimal duct.

(b) The presence of vascular connection between the nose and the nasolacrimal duct.

(c) The presence of a thick venous plexus (cavernous tissue in the mucous membrane of the inferior nasal turbinate) directly continuous with an analogous formation in the nasolacrimal duct.

(d) A definite location and shape of the nasal duct outlet. According to L. I. Sverzhevsky, there are four types of anatomical structure of the nasal duct outlet: (1) the end of the membranous nasal duct coincides with that of the bony nasolacrimal canal; (2) the membranous nasal duct ends with a wide opening below the end of the bony nasolacrimal canal; (3) the membranous nasolacrimal duct passes as a narrow canaliculus within the nasal mucosa; (4) the membranous duct ends with a narrow outlet much anteriorly or else posteriorly to the bony nasolacrimal canal. L. I. Sverzhevsky presumes that the latter three forms of nasal outlets contribute to the development of dacryocystitis upon the slightest change in the nose to a greater extent than when the duct outlet is actually in the vault of the inferior nasal meatus (the lst type).

(e) The presence of embryonal narrowings and folds of the mucosa in the lumen of the nasolacrimal duct, as well as diverticula.

The significance of the above formations in the process of scarring and development of stubborn strictures of the nasolacrimal duct even increases in cases of persistent catarrhs of the lacrimal passages sustained by the presence of twists and "bottle-necks" at the junction with the nasolacrimal duct.

It should be noted that ophthalmologists give inadequate attention to catarrh of the lacrimal passages, which always accompanies dacryocystitis (S. A. Dering). The involvement of the entire tear-draining tract in the pathological process is a factor confirmed by the pathohistological studies of B. L. Polyak and the clinical observations of P. Y. Tikhomirov. The latter associated the onset of lacrimation with the catarrhal swelling of the mucosa

of the nasolacrimal duct all along its length or at the nasal outlet, which caused a narrowing of the duct lumen rather than its complete stricture. At the same time the mucous membrane of the nose and inferior nasal turbinates was hyperemic and swollen.

PATHOLOGICAL ANATOMY

Dacryocystitis develops as a result of stagnation of lacrimal secretion caused by temporary or permanent, complete or partial stricture of the nasolacrimal duct.

The early stage of catarrhal inflammation of the lacrimal sac (dacryocystitis catarrhalis) is characterised by the signs common to simple inflammations, such as intensive dilatation of vessels, swelling of the mucous membrane, microcellular, infiltration of the submucous layer by polynuclear cells, and loosening of the epithelium. The latter enables cellular elements (leukocytes and lymphocytes) to penetrate first between the epithelial cells, then into the lacrimal sac where they mix with the stagnant secretion. Examination of the thickened, infiltrated wall of the lacrimal sac shows it to contain aggregations of follicle-shaped lymphoid cells, whereas the epithelial layer is found to have a large number of goblet cells partially filled with mucin and partially with the mucin discharged; in the latter case the cells shrink to a smaller size.

At this stage the lacrimal sac contents are of a greyish colour and consist of mucin and desquamated epithelium with an admixture of albuminous masses and a small number of lymphocytes.

Purulent dacryocystitis (dacryocystitis blenorrhoica) is characterised by a marked infiltration of the submucous and epithelial layers by leukocytes and lymphocytes which enter the lacrimal sac in great numbers and lend its secretion a purulent quality.

Distention of the lacrimal sac, atrophy of the epithelial layer, the flattening of epithelial cells and their degeneration into mucous cells may already be observed at the catarrhal dacryocystitis stage; moreover, one may observe the above-mentioned follicles grow in size and break through the epithelial layer to form epithelial defects (small ulcers) on the surface of the mucous membrane.

Later, when the process becomes purulent due to increased pressure from the stagnant purulent secretion and to toxins, the changes in the epithelium are accompanied by necrotic changes in the subepithelial layer as well. This process leads to the formation of ulcerated patches in the wall of the lacrimal sac through which the infection may spread to the surrounding tissues and bring about a phlegmon (see below concerning clinical signs). The usual site of pus breaking outside is the junction of the sac with the nasolacrimal duct.

In dacryocystitis, the lacrimal sac contains a large number of virulent microorganisms, usually pneumo-, staphylo- and strep-

tococci, which, however, may sometimes be accompanied by Pfeiffer's bacilli, Fränkel's and Friedländer's pneumobacilli, B. coli, pyocyaneus, fusospirillar symbiosis, tuberculous mycobacteria, B. fusiformis and a number of saprophytes. Since the bacteria in the lacrimal sac are more virulent than those in the conjunctival sac where they arrive from the former, the bacterial population, particularly the pneumococci, present a substantial danger to the eye, specifically its cornea, in view of the likeliness of ulcerous keratitis. That is why sufferers from purulent dacryocystitis should be barred from jobs involving frequent eye injuries, such as metal clutting, grinding, etc., or should be under obligation to use goggles.

CLINICAL SYMPTOMS

The most typical sign of marked dacryocystitis is lacrimation and pus discharge from the lacrimal puncta; a swelling caused by ectasia of the lacrimal sac may often be detected at the inner angle of the eye.

In the initial stage of the disease, i.e., during serous inflammation, when the lacrimal sac is not yet markedly dilated, and no swelling can be discovered at the inner angle of the eye, either by inspection or by palpation, and no secretion can be expressed from the lacrimal puncta by pressure on the lacrimal sac, the diagnosis is rather difficult.

If the lacrimal lake is not overfilled with tears, the functions of the lacrimal puncta and canaliculi are undisturbed, and there is no paralysis of the facial nerve, which disturbs tear conveyance as a result of disorders in eyelid closure and consequently in winking, the presence of lacrimation may indicate stricture of the nasolacrimal duct.

The expansion of lacrimal puncta and canaliculi, on the contrary, will point to the presence in the vertical knee of the lacrimal passages of obstacles to tear conveyance into the nose.

In such cases, additional methods of examination have to be used, such as diagnostic tests (of canaliculi and nose), trial irrigation of the lacrimal passages, probing and X-ray photography. These will be described below.

A marked distention of the lacrimal sac is usually seen in cases of prolonged obstruction of tear conveyance in the nasolacrimal duct, not necessarily due to complete stenosis. A distended sac is a resilient, fluctuating and painless swelling of round form and various sizes, usually located under the skin, at the inner angle of the eye, below the ligamentum palpebrae mediale.

The contents of a distended sac consist of pus mixed with mucin produced by the goblet cells of the lacrimal sac mucosa under

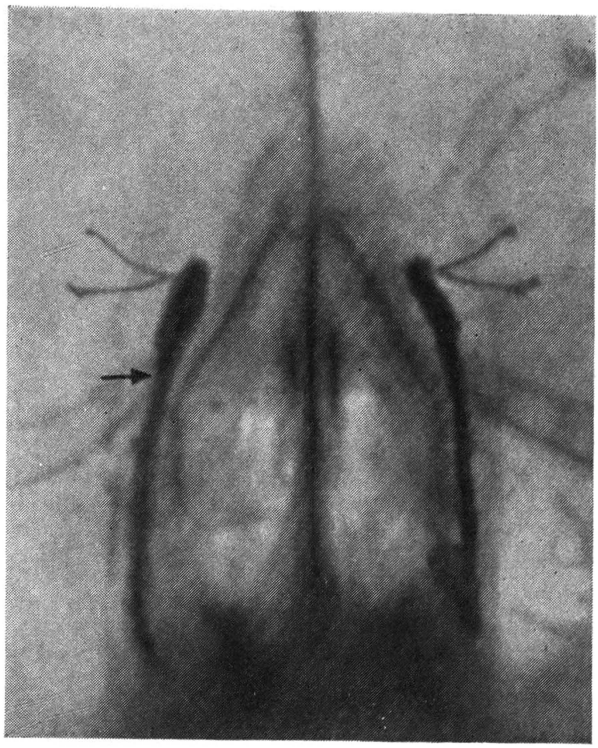


Fig. 63. Normal lacrimal passages. Expanded portions of the lacrimal canaliculi. A stricture in the place of communication of the sac with the nasolacrimal duct at right (see arrow)

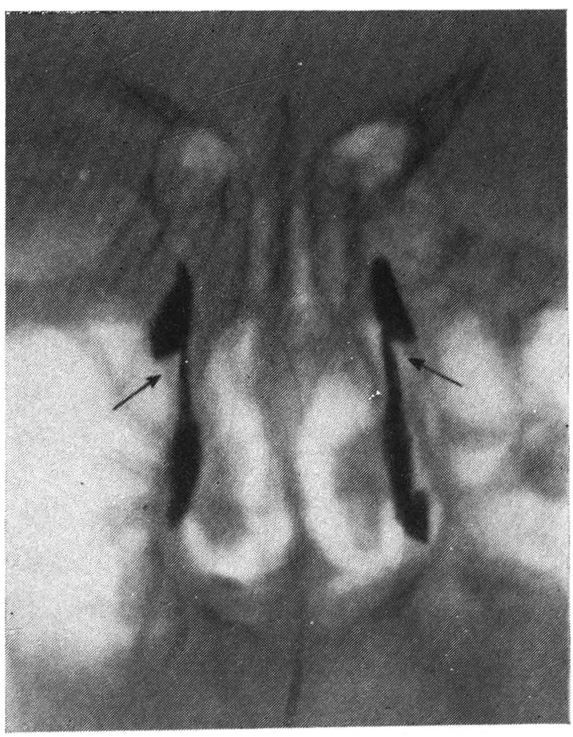


Fig. 64. A "bottle-neck" in the place of communication of the lacrimal sac with the nasolacrimal duct (see arrow), which disturbed tear drainage and caused distention of the lacrimal sac

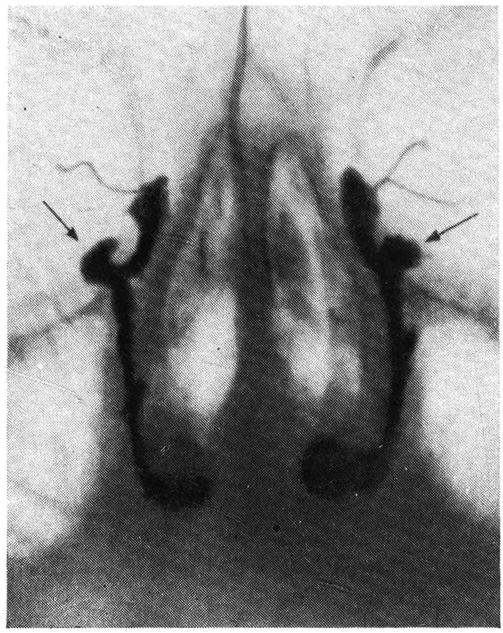


Fig. 65. Giant diverticula and protrusions in the lumina of the superior portions of the nasolacrimal ducts, particularly at right (see arrows)

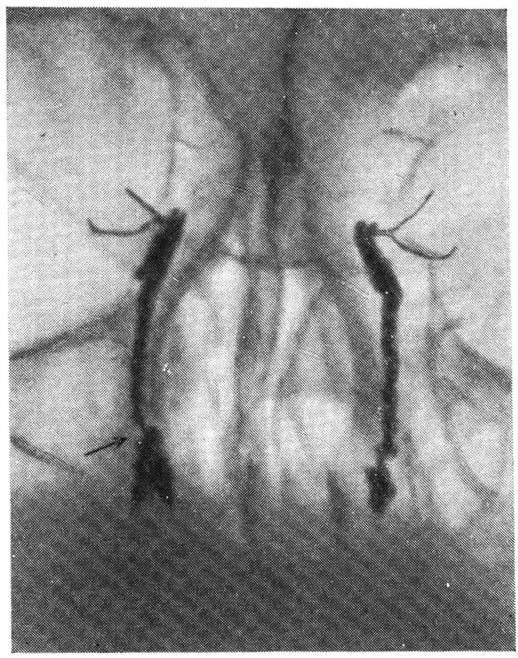


Fig. 66. Narrowing of the outlets of the nasolacrimal duct, particularly at right (see arrows)

Fig. 67. A marked stricture of the nasolacrimal ducts

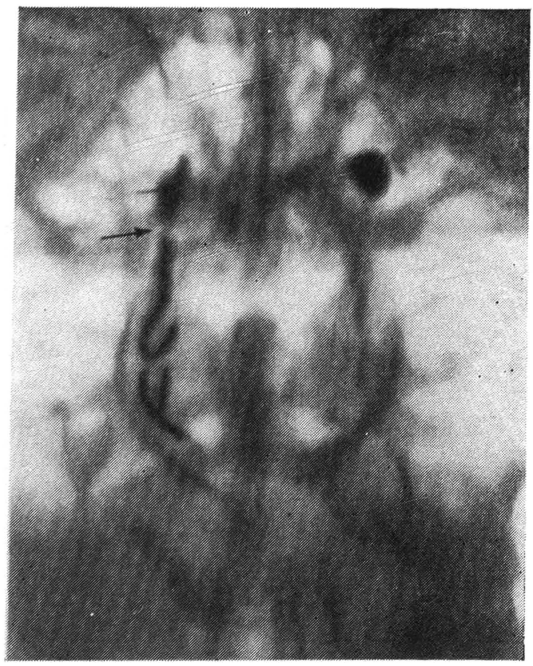


Fig. 68. Strictures in the right-side nasolacrimal duct. A lacrimal sac detached from the duct at left

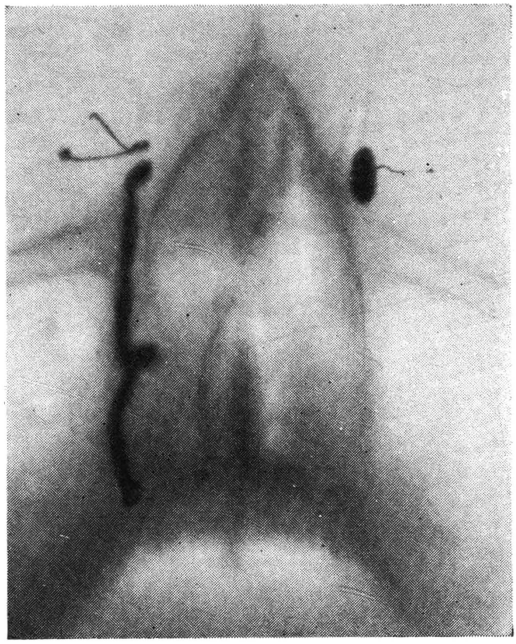


Fig. 69. Left-side dacryocystitis. The lacrimal sac is moderately distended

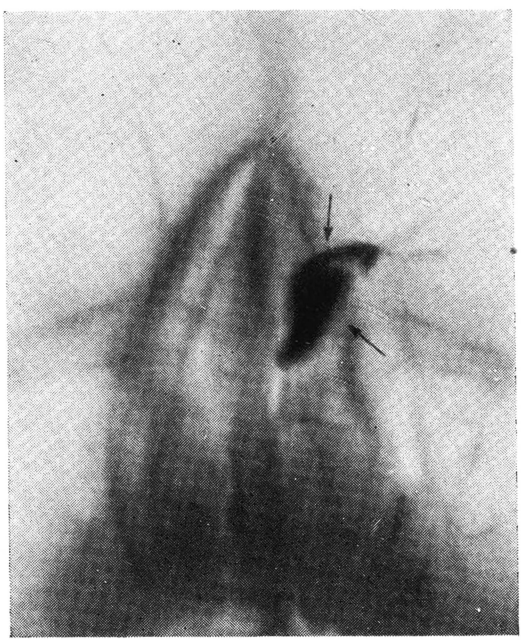


Fig. 70. The same case after rhinostomy. The lacrimal sac has decreased in size. The contrast medium has adequately filled the wide opening into the middle nasal meatus (see arrows)

the irritating effect of bacteria and toxins; these contents can be expressed through the lacrimal puncta by energetic pressure on the sac.

The anterio-inferior half of the lateral sac wall situated beneath the ligamentum palpebrae mediale is the most liable to distention, since it contains few elastic fibres.

Extending down- and outwards, the lacrimal sac grows beyond the limits of the lacrimal fossa. The distended sac is often seen ad oculos or felt on palpation as an elastic tumour located under the skin in the region of the frontal process.

In far-advanced cases where the sac is distended in every direction (i.e., not only downwards but also upwards) because of the weakened elasticity of the tissues of its walls exophthalmos and anterior displacement of the eyeball may be present.

The pressure of a distended lacrimal sac on the lacrimal fossa often causes the destruction of its bony floor, particularly the thin lacrimal bone, and the formation of an intranasal fistula of the lacrimal sac, which will be discussed below.

The course of dacryocystitis is often complicated by phlegmon of the lacrimal sac (flegmone sacci lacrimalis). The extension of the inflammatory process to the surrounding cellular tissue in an outbreak of acute symptoms is characterised not only by a number of local changes but also by systemic reactions, such as fever, debility, malaise, etc. The topical changes manifest themselves by marked erythema in the swollen area, pasty consistency, edema, and collateral palpebral edema. The phlegmonous edema sometimes grows to a considerable size to produce a likeness of facial erysipelas. With the progress of the disease the pus breaks outside in the lower portion of the swelling, i.e., below the ligamentum palpebrae mediale, whereupon the process becomes somewhat abated.

The shrinkage of the tumour as a result of evacuation of the phlegmon contents does not indicate recovery, however, since pus continues to discharge from the lacrimal puncta on pressure applied to the lacrimal sac and the nasolacrimal duct remains obstructed; pointing often leaves a persistent fistula continuously discharging pus (fistula sacci lacrimalis). Even upon the closure of the fistula, however the recurrence of phlegmonous inflammation is a rule rather than an exception.

The outcome of the inflammatory process in the wall often involves the growth of scar tissue strands in the wall of the lacrimal sac with formation of a few cavities within it as well as adhesion of its walls, obliteration of the lumen of the nasolacrimal duct and complete cessation of the discharge of tears and the sac contents into the nose. This in turn leads to distention of the sac and consecutive changes in its walls such as compression of the vessels, atrophy of the epithelium, and the flattening and degeneration of epithelial cells into mucous cells.

In cases where the scar tissue strands within the walls of the lacrimal sac disturb the connection with the other portions of the lacrimal passages, there is a danger of lacrimal dropsy (hydrops sacci lacrimalis). The latter turns into a painless, fluctuating cyst of invariable size, sometimes as large as a hazelnut.

It was noted above that distention of the lacrimal sac may cause the destruction of the lacrimal bone, while its rupture may give rise to an intranasal fistula of the lacrimal sac through the defect in the lacrimal bone.

Such fistulas have been studied by means of X-rays and described in 1920 by the ophthalmologist Szyli, who called them the "fistula sacci lacrimalis interna". He believed that these fistulas arising both in complete stenosis and in incomplete obliteration of the nasal duct may be identified only with the aid of roentgenography. We, however, share the opinion of F. S. Bockstein to the effect that such fistulas can also be diagnosed by rhinoscopy (see "Differential diagnosis").

The case below is given for illustration. In 1959 at the Helmholtz Institute of Ophthalmology we examined a patient with a phlegmon of the left lacrimal sac and intranasal fistula. On pressure applied to the left lacrimal sac, particularly when the head was inclined forwards and downwards, a pale yellowish liquid discharged from the left side of the nose. Rhinoscopical examination with pressure on the sac showed the liquid to appear not under the inferior nasal turbinate, i.e., through the nasal duct outlet, but in the portion corresponding to the location of the lacrimal sac on the lateral wall of the nasal cavity, under the inferior nasal turbinate. The paranasal sinuses subjected to X-ray examination proved to be transparent.

The pus flowing through the intranasal fistula and containing virulent microbes may enter the maxillary sinus and the ethmoid labyrinth through the sulcus uncinatus and cause their suppuration.

The likelihood of a secondary disease (suppuration) of the ethmoid labyrinth and maxillary sinus in a purulent inflammation of the lacrimal sac has been established by a number of clinicians. D. M. Rutenburg, in particular, has described a case of pyosinus of the ethmoid labyrinth and the antrum of Highmore healed by means of an endonasal opening of these sinuses.

The complications of lacrimal sac phlegmon where the pus breaks backwards, into the orbital cavity, have a particularly severe course. Such complications may arise by extension of the process through blood and lymph vessels. The symptoms of phlegmon eruption into the orbit are abscesses and thrombophlebites with phlegmon of the retrobulbar space, which may lead to intracranial complications and inflammations of the optic nerve.

The clinical sign of dacryocystitis in the newborn is an insignificant pus discharge from the conjunctival sac without symptoms

of distention of the lacrimal sac. Pressure on the latter, however, yields a liquid secretion. At first this is sterile, but later becomes infected due to stagnation. The connective-tissue membrane usually ruptures within a few days of birth, either spontaneously, when the baby screams, or following insignificant manipulations, such as massage of the lacrimal sac, administration of medicines, etc. In a few cases, the membrane does not break spontaneously, and probing has to be applied.

DIAGNOSIS

Diagnostic tests and X-ray examination of the lacrimal passages; their significance in identifying the site and character of lacrimal disorders. It has been noted that lacrimation is basically caused by an organic lesion in a portion of the lacrimal passages, primarily a stricture and stenosis, and a disorder of functional and reflex origin; the latter cause of lacrimation has been described above.

In order to locate the site of the process in organic lesions of the lacrimal passages and to identify the character of hypersecretion in functional disorders, a number of diagnostic tests, as well as roentgenology of the lacrimal passages are employed, as has been mentioned above.

These methods supplementing ophthalmological and rhinological examination are not only of diagnostic value, but also play a part of no small importance in treatment and prognostication.

Among the host of diagnostic tests the most popular are those suggested by West, namely, the canalicular and the nasal.

The canalicular test is intended to ascertain the functional pumping capacity of the lacrimal canaliculi, i.e., the active patency of the lacrimal passages. The test is essentially based on the fact that with normally functioning lacrimal canaliculi the liquid injected into the lacrimal sac must pass into the lacrimal sac in winking.

Methods of examination. The conjunctival sac is filled repeatedly with one drop of a 2 to 3 per cent collargol solution or 1 per cent fluorescin at intervals of 2 to 3 minutes. By winking lightly the staining substance is expelled from the conjunctival sac whereupon the latter is carefully washed out to remove the residual stain.

If the functional pumping capacity of the lacrimal canaliculi is normal, the stained solution will in half-a-minute to two minutes leave the conjunctival sac and enter the lacrimal sac. By pressure on the latter the solution will be pushed to the lacrimal puncta and back to the conjunctival sac and be observable there.

In case the stain does not appear from the lacrimal punctum the lacrimal sac should be lavaged with a physiological solution through the inferior lacrimal punctum; if the collargol has entered the sac it will appear from the superior lacrimal punctum.

In a positive canalicular test indicating the normal function of the lacrimal canaliculi, collargol flowing through the lacrimal canaliculus from the conjunctival sac into the lacrimal sac or even into the nose, which occurs in case of partial or complete patency of the nasolacrimal duct, is pushed back into the conjunctival sac on pressure applied to the lacrimal sac.

If, however, with perfect patency of the lacrimal canaliculi, which is verified by probing, a correct position of the lacrimal puncta and the absence of strictures in the nasolacrimal duct, the nasal test is, nevertheless, negative or markedly slow, as evidenced by retention of the stained solution in the conjunctival sac, then there is reason to suspect a functional disorder of tear secretion, i.e., disturbance of the suction capacity of the lacrimal canaliculi.

The nasal (colour) test. This test pursues two aims: (1) to rule out the relationship of lacrimation to hypersecretion; and (2) to verify the patency of the lacrimal passages.

Procedures. The conjunctival sac is filled with one or two drops of a 5 per cent collargol solution or 2 per cent fluorescin, whereupon the patient is asked to wink a few times without closing the eyelids too firmly. In case of a normal patency of the nasolacrimal duct the liquid will in 40 or 60 seconds leave the conjunctival sac and run into the nose, the eye will clear up, and the cotton tampon inserted preliminarily into the inferior nasal meatus, close to the nasal duct outlet, will become stained. In this case the test is considered positive. The faster the cotton takes on colour the better, consequently, is the function and the higher the speed of passage of the solution from the conjunctival sac.

As evidenced by F. S. Bockstein's studies, normally one drop of collargol is pumped out of the conjunctival sac in 10 to 30 seconds; the whole test made by injection of three drops at brief intervals thus usually takes one or two minutes at the most.

If in the presence of lacrimation the nasal test is positive the suspicion of mechanical obstruction of the lacrimal passages and functional disorders should be discarded. Reflex causation may then be suspected, which is often corroborated by the adequate evidence of ophthalmological and rhinoscopic examinations (concerning reflex lacrimation, see above).

A negative or slow nasal test, whereby the cotton inserted into the inferior nasal meatus retains its own colour, indicates a defect of the lacrimal passages, namely, the absence of active patency; this, however, is by no means characteristic of stricture in the nasolacrimal duct since the reason may well be a functional disorder of tear conveyance through the canaliculi or dislocation of the lacrimal puncta.

Duplicate collargol test. B. N. Lebedevsky modified West's nasal test into what he called West's duplicate test for identifying the rhinogenous character of lacrimation depending on transient stric-

tures of the nasal duct outlet. as well as for deciding on the expediency of a nasal operation.

Procedures. After the conjunctival sac has been filled with a 2 to 3 per cent collargol solution a cotton tampon is used to take a smear sample from the vault of the inferior nasal meatus into which the nasal duct opens. If the tampon takes no stain or takes it in 5 to 30 minutes' time, the test is repeated on the following day, after a preliminary adrenalin administration to the inferior nasal turbinate and the inferior nasal meatus. In case the results are the same as the day before, i.e., if the test is negative, the lacrimation should not be regarded as being of rhinogenous origin and cannot be eliminated by curing pathological symptoms in the nose.

In a positive West's duplicate test with adrenalin, when the collargol is detected in the nose not within 30 minutes of its being injected into the conjunctival sac but in a much briefer time (close to normal) the lacrimation may be thought to be of rhinogenous origin. In such cases B. N. Lebedevsky has discovered deviations of the nasal septum, simple or hypertrophic rhinitis, adenoids or adhesion of the inferior nasal turbinate to the lateral wall of the nose. B. N. Lebedevsky's modification has also proved valid in our studies at the Helmholtz Institute of Ophthalmology.

Irrigation of the nasolacrimal duct is made to determine its patency in case of a negative nasal test.

Irrigation procedures. Following anesthesia of the conjunctival sac with two or three drops of dicaine solution, 0.5-1 per cent, a cone-tipped probe is used to dilate the inferior, less commonly the superior lacrimal punctum and then the lacrimal canaliculus (with Bowman's blunt probe No. 1 or No. 2) down to the lacrimal sac itself. The canaliculus having been dilated, a special blunt needle set on a 1-2 g syringe is inserted into it until the needle has touched the bone; whereupon it is withdrawn 1 or 2 mm for a slow injection of physiological or boric acid solution. With a patent nasolacrimal duct the liquid will easily pass into the nose; if, however, a certain resistance must be overcome, either a stricture or granulations in the duct are probably present. In complete stenosis the liquid is forced back through the superior lacrimal punctum or bypasses the needle on its way out through the canaliculus.

Probing is used to determine the site and nature of stenosis.

Procedures employed in probing. Following anesthesia (see above) a cone-tipped probe is used to dilate the inferior or superior lacrimal punctum, whereupon, the eyelid being drawn outwards, Bowman's probe No. 1 or No. 2 is inserted into the canaliculus in the horizontal direction. When the probe end has reached the bone (the floor of the fossae lacrimalis), the probe is turned to the vertical and cautiously slipped through the sac into the nasolacrimal duct.

The literature contains numerous reports of grave complications following irrigation and particularly probing, such as edema

of the cheek, severe headaches, thrombophlebitis of the orbit and the v. centralis retinae, which resulted in blindness, phlegmon of the orbit with a loss of vision, phlegmon of the lacrimal sac and even acute meningitis. In view of the fact that irrigation and probing facilitate direct penetration of pathogenic microbes into the tissue, should there be a casual injury to the mucosa of the lacrimal passages, Stock recommends abstention from these procedures in the presence of suppuration or phlegmon of the orbit, and, in case of emergency, performance of these manipulations in hospital surroundings.

F. S. Bockstein has consistently abstained from the diagnostic probing of the nasolacrimal duct, using this method only for examining the patency of the lacrimal canaliculi; he believed that "in obvious cases probing was superfluous and that in doubtful cases the probing data were not sufficiently reliable".

The X-ray method, as many specialists believe, is more accurate and safer, though more complicated.

The X-ray method of examining the lacrimal passages. The first reports on this method were made by Ewing in 1909. In 1911, Aubaret reported eleven cases of X-ray examination of the lacrimal passages to a congress of French ophthalmologists. A major contribution to the development and propagation of this method was made in 1914 by Szyli.

The first to introduce this method in the Soviet Union was F. S. Bockstein who, at a meeting of the ophthalmological society in 1922, demonstrated X-ray films of the lacrimal passages, and two years later, in 1924, published an article on this subject. Drawing on extensive material (100 cases) he outlined the range of indications for X-ray examination of the lacrimal passages and its clinical value. B. L. Polyak was the first among the ophthalmologists to tackle this problem (1926).

Procedures of X-ray examination. The contrast medium used for the purpose may be 40 per cent lipiodol, 20 per cent iodipin, 30 per cent iodolipol, thorotras, sergosin and bismuth nitrate in mixture with paraffin oil; the latter's advantages are its longer retention in the lacrimal sac and the nasolacrimal duct, an adequately contrastive shadow and nearly complete absence of irritation in the lacrimal passages.

After irrigation, as has been described above, the duct is filled with a contrast mass in an identical manner. It should be borne in mind that both in irrigation of the duct and introduction of the mass the patient's head should be inclined forwards and downwards as far as possible.

The films are best made in two mutually perpendicular projections: the sagittal and the lateral. The former gives the principal pictures, while the latter should be regarded as accessory and used for a detailed study of the X-ray picture.

When positioning the patient it should be remembered that the most advantageous is the mento-nasal or the anterior semi-axial projection, as well as the position where the cassette touches upon the chin and the tip of the nose. The films thereby obtained show distinctly the lacrimal canaliculi against the background of the orbits, as well as the entire length of the nasolacrimal duct (Fig. 63). At the same time, the bones of the base of the skull produce downward shadows superimposed on the dental region.

The basic advantage of this method is the possibility of identifying narrowings, folds, strictures, stenoses and diverticula in the nasolacrimal duct, as well as of specifying their location (degree of stenosis), extension, the patency of the duct and the nature of narrowings (Figs. 64-70).

X-ray examination yields highly valuable data for decision on probing as a therapeutic manipulation and facilitates discovery of the causes of failures in probing the duct, such as the presence of bends, strictures, flexures, and "bottle-necks". For example, if a diffuse narrowing of the duct due to granulations, as in tuberculosis, is revealed by X-ray examination, probing is contraindicated, but at the same time is perfectly advisable as a therapeutic procedure for a limited, ring-shaped narrowing of the lumen.

The X-ray method aids in working out a correct plan of treatment, in selecting the most suitable surgical procedure and in proper orientation at operation, since it provides adequate material for understanding the topographical relationships between the lacrimal passages, the lacrimal sac in particular and the surrounding bony tissues, such as the nasal bones, the middle and inferior nasal turbinates, the paranasal sinuses, especially the ethmoid labyrinth, as well as the orbit and teeth.

Moreover, roentgenography helps evaluate the immediate results of surgical treatment, the degree of restored duct patency, the presence and character of the anastomosis, the condition of the sac, the width of its lumen, etc. (see Figs. 69 and 80).

Finally, X-ray examination makes it possible to differentiate between a catarrhal and a cicatricial narrowing of the lacrimal passages by investigating the relief of the mucous membrane. The former is marked by small folds caused by swelling of the mucous membrane; the contrast liquid column in the duct lumen assumes a distinctly festoon shape. In a cicatricial narrowing the duct walls are smooth.

DIFFERENTIAL DIAGNOSIS

Although marked forms of dacryocystitis are not difficult to identify, nevertheless, with the disease taking a peculiar course they have to be differentiated from other diseases with similar signs.

These comprise, first and foremost, *cysts of the lacrimal sac* developing either from the sac diverticulum or from the glands contained

in the sac. Pressure on the cyst fails to express its contents into the nose or through the lacrimal puncta, though the lacrimal passages are completely patent. This often leads to such cysts being confused with a distended sac, the walls of which contain fibres of scar tissue hampering the sac connections with the adjacent portions of the lacrimal passages, as a result of which the sac turns into a fluctuating tumour invariable in size even on pressure (hydrops sacci lacrimalis).

The similarity between both forms consists in the liquid failing to enter the nose or lacrimal puncta on pressure applied to the lacrimal sac, both in the case of a cyst and of dropsy. The nature of the disease can be identified either by X-rays, since in the presence of a cyst the nasolacrimal duct is patent and in dacryocystitis it has a stricture or stenosis, or by using the following procedure recommended by F. S. Bockstein. Upon the dilatation of the lacrimal punctum with Bowman's probe, the latter is inserted into the lacrimal canaliculus down to the very lacrimal sac and then withdrawn gradually with continuous finger pressure on the swollen area.

If the removal of the probe is followed by a flow of secretion and escape of the whole or even part of the residual contents through the lacrimal punctum, this will be evidence of a distended lacrimal sac containing cross-fibres, in other words, of dropsy.

Dropsical distention of the lacrimal sac should be differentiated from mucocele of the ethmoid labyrinth. The latter formation, however, is located above the internal ligament, while the bulk of the distended lacrimal sac is situated beneath the ligament. Moreover, an X-ray examination of the paranasal sinuses may yield adequate information for detecting a cystoid distention of the ethmoid labyrinth, which has been thrown into one wide cavity.

An external fistula of the lacrimal sac should be differentiated from *a fistula of the superior maxillary bone* caused by osteomyelitis. The latter's characteristic sign, however, is an exposed tuberous bone affected with caries always discovered by probing at the fistular channel.

An external fistula of the lacrimal sac may also be confused with *a fistula of a dental cyst*. They can be differentiated only by the site of the fistular opening; that caused by a dental cyst is usually found below the orbital boundary, whereas the lacrimal sac fistula is discovered either on a level with the orbital boundary or somewhat higher up and more towards the nose.

Diagnostic irrigation through the lacrimal puncta is permissible only upon liquidation of the acute symptoms. In such cases the passage of liquid through the nose indicates patent lacrimal passages and an intact lacrimal sac, whereas liquid escape through an external fistula is evidence of its being connected with the lacrimal sac.

Phlegmonous inflammations of the lacrimal sac with or without fistulas are sometimes difficult to differentiate from *empyemas of the paranasal sinuses*, particularly of the ethmoid labyrinth and, though less commonly, of the frontal and maxillary sinuses. Apart from the rhinological and X-ray examinations of the paranasal sinuses permitting either to rule out or to establish pathological affection, the diagnosis is also specified by means of locating the site of the fistula or of an immature tumour: in empyema of the frontal sinus the fistula lies above the ligamentum palpebrae mediale, while in empyema of the ethmoid labyrinth it lies not only above the ligament but closer to the nasal dorsum, whereas the phlegmon of the lacrimal sac is characteristically located below the ligament.

Probing and irrigation for verifying the diagnosis in this group of cases are likewise contraindicated for fear of infecting the surrounding tissue.

A phlegmonous inflammation of the lacrimal sac extending to the surrounding tissues may be mistaken for *phlegmon of the orbit* and for *facial erysipelas*. Case report 8 given in Chapter III describes a phlegmon of the lacrimal sac extending to the orbital cellular tissue and at first erroneously diagnosed as an orbital phlegmon of rhinogenous origin.

The need for differentiating phlegmons of the lacrimal sac and subperiosteal abscesses confined to the superointernal angle of the orbit has already been discussed in Chapter III.

As it was noted above, a phlegmonous inflammation of the lacrimal sac is accompanied—apart from external fistulas—by *intranasal fistulas of the lacrimal sac* arising upon destruction of the floor of the lacrimal fossa. Such *intranasal fistulas* have to be differentiated from suppuration of *the ethmoid cells*, since both mentioned forms are marked by a characteristic purulent streak in the middle nasal meatus. To clarify the condition of the ethmoid labyrinth the X-ray method of examining the paranasal sinuses is used, as well as the following experiment: pressure is applied to the distended lacrimal sac and, should its contents not be expressed through the lacrimal puncta but escape into the nose and appear under the inferior nasal turbinate, the presence of an intranasal fistula of the lacrimal sac may be taken for a fact.

In cases where the fistula is hidden beneath the middle turbinate or the ethmoid cells, since, according to Onodi, the lacrimal fossa is covered with the middle nasal turbinate in four out of every ten cases, F. S. Bockstein uses the following procedures to specify the place of pus eruption into the nose, under the inferior turbinate or in the middle nasal meatus. The middle and inferior nasal meatuses are packed with a small piece of cottonwool, whereupon the lacrimal sac is filled with a 5 per cent collargol solution through the lacrimal puncta. In the presence of an intranasal fistula the cotton in the middle nasal meatus takes on a stain.

Specific tuberculous changes in the region of the lacrimal sac and the nasolacrimal duct are rarely encountered. If they are, however, their signs will be as follows: (1) patency of the nasolacrimal duct in irrigation, since tuberculous granulations do not make it impassable; and (2) fistulas, bone death, and cold abscesses. We are commonly confronted with secondary dacryocystitis in patients with tuberculosis of the nasal cavity.

The same, in effect, is true of secondary dacryocystitis in patients with tertiary syphilis of the nose and rhinoscleroma.

In this connection there is full reason to subscribe to the common view that dacryocystites in tuberculosis, syphilis, ozena and scleroma have identical symptoms as regards their clinical, as well as pathoanatomical and bacteriological pictures.

PROGNOSIS

The existence of dacryocystitis, even if inactive, is a danger to vision and to the eye, since in certain cases this disease causes pneumococcic ulceration of the cornea (ulcus serpens corneae). In such cases the eye is especially exposed to destruction. The constant contamination of the conjunctival sac with pus escaping from the lacrimal sac and containing various pernicious germs may lead to stubborn blepharitis and blepharoconjunctivitis.

The peril to the eye becomes aggravated even during the phlegmonous inflammation of the sac, particularly when there is a discontinuity, however slight, in the epithelial cover of the cornea.

Prognostication, like therapy, makes wide use of the canalicular test. Surgical interference to provide anastomoses between the lacrimal sac and the nose is indicated where the functional capacity of the canaliculi is retained in adequate degree. At the same time, the outlook for surgical treatment of dacryocystitis with stenosis of the nasolacrimal duct is unfavourable when the functions of the canaliculi are disturbed. In the opinion of F. S. Bockstein and a number of other specialists, however, the significance of this test is not absolute, since a negative or slightly positive test is not enough to establish full and irrevocable loss of function by the canaliculi.

Therefore, these data are not yet an absolute contraindication for surgical interference nor are they obvious enough for the outlook of rhinotomy prognosis to be considered utterly hopeless in regard to the cessation of lacrimation following an operation.

TREATMENT

Treatment of dacryocystitis is exclusively by surgery.

In the presence of unstable strictures of the nasal duct outlet (as verified by B. N. Lebedevsky's duplicate collargol test) which are due to changes in the inferior portion of the nose, as well as in

reflex lacrimation of rhinogenous origin, the following types of operation are indicated: resection or galvanocautery of the nasal turbinates (primarily the inferior), submucous resection of the nasal septum, excision of spurs, ridges, polyps, etc.

Removal of the lacrimal sac is practised only as an exception today. This operation has been completely superseded by dacryocystorhinotomy, both external, usually made by ophthalmologists, and endonasal, commonly practised by rhinologists.

"Dacryocystorhinotomy claims to preserve all the positive aspects of extirpation and eliminate its negative aspects, i.e., continued lacrimation", writes M. I. Averbach.

The methods of surgical intervention, i.e., dacryocystorhinotomy and the endonasal approach to the extirpation of the lacrimal sac, as well as indications for surgery are described in Chapter VII.

As regards dacryocystitis in the newborn, a failure to disrupt the connective-tissue membrane at the blind end of the nasal duct outlet by repeated forcible pressure on the lacrimal sac from above downwards should be followed by retrograde probing.

This method of probing, suggested by F. S. Bockstein, makes it possible to break the thin membrane and thus provide a passageway for tear discharge into the nose.

Retrograde probing of the nasal duct outlet in the newborn with dacryocystitis, particularly in infants under 6 months, has proved effective in the extensive experience of the Helmholtz Institute of Ophthalmology (F. I. Dobromylsky and F. Y. Mogilevskaya).

The manipulation is made with a button-tipped probe (Fig. 71*a*), its tip bent at right angles 3 to 4 mm from the probehead. A special handle, selected from a set of foreign body extractors, is fitted on the probe for greater steadiness in slipping it under the inferior nasal turbinate. Turning the probe at the site of its fixation with the handle screw (Fig. 71*b*) serves to direct its head left or right, depending

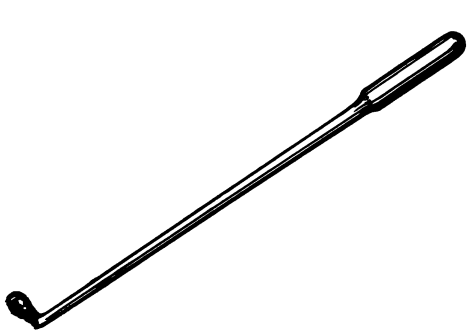


Fig. 71a. A probe for retrograde probing

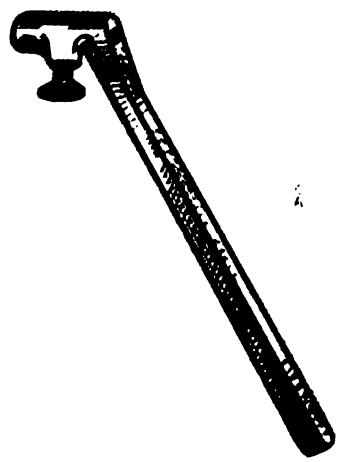


Fig. 71b. A handle for the probe

on the side of affection. The head is passed under the inferior nasal turbinate close to its vault and as far rearwards as possible, though not farther than half the length of the turbinate, and also outwardly; whereupon the probe is withdrawn gradually, its tip being pressed to the membrane in order to break the latter. The manipulation is carried out without a nasal retractor because of the small size of the nasal vestibule, the right forefinger lifting the tip of the nose to offer a better view of the inferior nasal turbinate.

The rupture of the membrane often produces a crackling sound: it is sometimes followed by a small escape of blood, or scraps of membrane may be found on the probe tip.

Probing usually has to be applied twice; only in one out of every three cases is a single procedure sufficient.

VII

Methods of Surgical Treatment

"An ophthalmologist may undertake a purely orbital operation which he may be quite sure of being within his competence, and quite unexpectedly encounter an extension of the process into one of the adjacent sinuses". (S. S. Golovin).

An eye surgeon can never be confident that following the opening of the orbital cavity he will not have to extend his interference to the paranasal sinuses as well. That is why S. S. Golovin urged eye surgeons to study the surgical procedures used for paranasal sinuses. As early as the 1890's he had expressed the view which Axenfeld arrived at much later (1930). An ophthalmologist, the latter wrote, who desires to "practise orbital surgery within fairly broad limits and be capable of coping with every difficulty involved therein should have personal experience in the surgical treatment of the paranasal sinuses via the orbit".

The operation of combined exenteration of the orbit and the adjacent sinuses (exenteratio orbito-sinualis) developed by S. S. Golovin back in 1907 for removal of malignant tumours extending beyond the orbital limits proves the urgency of the demands made upon ophthalmic surgery. They appear even more urgent when it is recalled that the method of extraorbital orbito-sinual exenteration suggested by V. P. Filatov and N. K. Lysenkov comprises two steps, i.e., the opening of the paranasal sinuses and the extirpation of the tumour from the orbit.

"It is practically important", S. S. Golovin wrote, "that the ophthalmologist should be capable of coping with related diseases and employing the major surgical procedures involved"... "he should be able to reach into the adjacent sinuses, bypassing the eye, i.e., extraorbitally, in order to avoid injury to the eye so far as possible."

Endonasal surgical interference may prove successful in the treatment of some orbital diseases, such as periostitis, collateral edema, subperiosteal abscess and other rhinogenous diseases, but in most of the cases the ophthalmologist has to deal with the most rational is the external opening of the paranasal sinuses. That is why we describe only external radical operations in the present volume without regard for the methods of endonasal interference.

In our view, the exposition of surgical procedures in the treatment of orbital diseases associated with lesions of the paranasal sinuses should best start with the methods of periorbital operations, i.e., the opening of the paranasal sinuses (A) and followed by description of the techniques of opening the orbit (B). Only after adequate knowledge has been gained concerning these simple operations on the paranasal sinuses and the orbit will it be comparatively easy to study complicated surgical procedures, such as combined exenteration of the orbit and extraorbital orbito-sinual exenteration (C), i.e., orbital operations extending beyond the orbit.

A. OPERATIONS ON THE PARANASAL SINUSES

1. The Opening of the Maxillary Sinus

Below are presented the types of external radical operations on the maxillary sinus.

Methods of External Opening of the Maxillary Sinus

Facial Methods	*Naso-Facial Methods*
1. The opening of the maxillary sinus by resection of its facial wall after Desault and Küster.	1. The opening of the maxillary sinus by resection of the facial and nasal walls with retention of the pyriform spine (Caldwell-Luc).
2. The opening of the maxillary sinus through the alveolar process after Busch, Cooper and Ziem.	2. The opening of the maxillary sinus by resection of the facial and nasal walls and removal of the pyriform spine (Denker).

The facial methods of opening the maxillary sinuses after Desault and Küster, as well as the surgical approach to them via the alveolar process (Busch, Cooper and Ziem) are interesting only in the historical context, since they are no longer in use, being incapable of ensuring constant drainage of the sinus and its consistent treatment.

NASO-FACIAL METHODS

Caldwell-Luc method. This method, suggested by Caldwell in 1893 and by Luc in 1897, consists essentially in a broad resection of the facial wall of the maxillary sinus in the region of the canine fos-

sa and cleansing of the sinus from its pathological contents through a hole made in the bone, as well as in providing for a nasal counter-opening sized 2 by 2 cm in the medial wall of the sinus. The later treatment and irrigation of the sinus are effected through this communication formed in the inferior nasal meatus under the inferior nasal turbinate (Fig. 74). Caldwell-Luc operation, just as all operations on the paranasal sinuses, is made under local infiltrative subperiosteal anesthesia with a 0.5-1.0 per cent novocaine-adrenalin solution, injected into the intermediate fold of the gingiva and the entire region of the canine fossa up to the outlet of the infraorbital nerve. In hypersensitive subjects the gum in addition is painted with a 10 per cent cocaine solution, and subperiosteal anesthesia is effected in the initial part of the nasal cavity, i.e., the floor and the lateral wall. A gauze strip, soaked in a 5 or 10 per cent cocaine solution, should be packed into the inferior nasal meatus.

The operative techniques. The patient is laid on the operating table, the head tilted backward, the neck propped on a bolster. To avoid aspiration of blood a gauze tampon is introduced between the cheek and the rear teeth of the upper and lower jaws. A horizontal incision is made and carried down to the bone (Fig. 73) along the intermediate fold of the upper gingival mucosa from the midline to the third molar tooth; the frenulum should not be cut, the upper lip and corner of the mouth are elevated and everted with a blunt retractor held by an assistant; following the elevation of soft tissue together with the periosteum until exposure of the canine fossa, a gouge is used to cut through the facial wall where it is thinnest, i.e., in the canine fossa (Fig. 72). The bone opening thus formed, which is enough to insert Hajek-Claus forceps, is dilated downwards, to the level of the alveolar process, i.e., to the floor of the maxillary sinus; upwards, to the outlet of the infraorbital nerve, care being taken to avoid its injury, and towards the nose, up to the lateral wall and short of the pyriform aperture. This resection lays the sinus sufficiently open to view and accessible for removal of its pathological contents. The degenerated polypiferous mucosa is cautiously separated from the bone with an elevator and removed with a sharp curette or Brünings' fenestrated forceps. Special care must be taken to avoid injury to the roof of the maxillary sinus, which may introduce infection into the orbital contents. The formation of a counter-opening into the nose (Fig. 74) following the resection of the medial wall of the sinus is the most difficult procedure in the operation; it should be remembered that an adequate communication with the nose is the sole prerequisite of effective surgical interference. The resection of the medial wall within the inferior nasal meatus should be made in the following way: the bone in the anterior portion is cut with a gouge placed vertically, and then turned to the horizontal to cut the floor where the bone is especially thick. The strikes should be light enough to avoid injury to the mucous membrane. It is unnec-

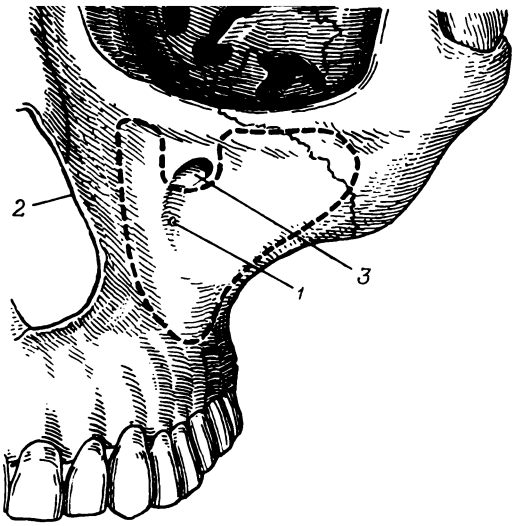


Fig. 72. Projection of the maxillary sinus on the anterior wall of the superior maxillary bone (dotted line)
1 — fossa canina; *2* — aperture piriformis; *3* — infraorbital foramen

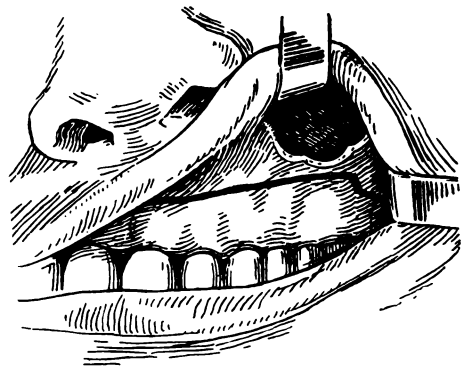


Fig. 73. The line of incision along the intermediate gingival fold and the opening formed on the facial wall of the maxillary sinus

essary to use the gouge for making incisions in the upper portion, under the place of attachment of the inferior nasal turbinate, as well as in the posterior portion; after the nasal mucosa has been separated, the bone may be caught with Pean's or Kocher's forceps in the antero-inferior portion and broken in the supero-posterior portion, where it is rather thin. It now remains to smooth out the sharp edges of the bone defect with a broad curette and remove the portion of the nasal mucosa corresponding to the gap in the bone. A probe is inserted into the nose to push its mucosa into the maxillary sinus, where it is seized with a pincers and cut with a thin scalpel along the margins of the bone defect. Plastic surgery is employed to speed up epithelial growth in the sinus walls. Specifically an inverted

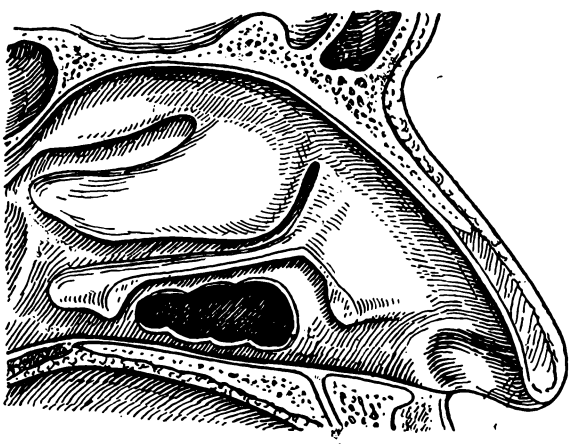


Fig. 74. The newly-formed aperture (counteropening) connecting the maxillary sinus with the nasal cavity (view from the nose following the removal of the inferior nasal turbinate)

U-shaped incision is made in the anterior, posterior and superior portions, and a skin flap formed thereby, attached by its base below, is grafted on the floor of the sinus which is packed with tampons to promote healing. The incision in the gum is sutured. The reactive swelling of the cheek which sometimes grows to a considerable size does not persist for long, as a rule.

Among the postoperative complications is lacrimation caused either by tamponade or by injury to the nasolacrimal duct. The formation of secondary fistulas along the incision may follow an inadequate closure of the lips of the wound. The most severe complication of Caldwell-Luc operation is an abscess or phlegmon of the cheek, which may be due to an excessively large and highly placed incision of the gum extending to the mucous membrane of the cheek.

It is a matter of common opinion today that formation of a flap, tamponade of the maxillary sinus and suturing of the incision of the gingival mucosa should be avoided to ward off the danger of the above-mentioned complications.

Tamponade should be used only for severe hemorrhages, and sutures should be applied only when there is likelihood of the wound lips turning in and the wound surfaces failing to heal, as encountered in atrophy of the alveolar process of the maxilla. It is unnecessary to suture the wound in young and strong subjects.

Denker's method. This method, which its author himself called a modification of Caldwell-Luc operation, is a combination of the latter with the suggestions of other authors. Local anesthesia is induced in the same way, the only difference being the indispensable subperiosteal anesthesia of the lateral wall and floor of the nasal cavity.

The operative techniques. A square of gauze folded a few times is placed between the posterior teeth to prevent choking with blood. The operative field is exposed by means of three blunt hooks: two are used to elevate the upper lip and one to draw away the mouth corner. The incision is made along the superior labial fold and carried down to the periosteum; it is begun above the wisdom tooth, carried to the frenulum, just as in Caldwell-Luc operation, and extended 1 cm to the opposite side. A raspatory is used to push apart the soft tissues and expose a broad length of the facial wall of the maxillary sinus, down to the apertura piriformis, whereupon the mucosa of the lateral wall of the inferior nasal turbinate and the adjoining part of the nasal floor is separated from the bone. To avoid casual injury to the nasal mucosa, a strip of gauze is inserted between it and the exposed bone of the lateral nasal wall. The mucous membrane of the lateral nasal wall is separated along 4 cm posteriorly to the pyriform incisure. After the frontal (facial) wall has been freed from soft tissues and the internal (nasal) wall of the superior maxillary bone from the nasal mucosa, the sinus is opened from the side of the canine fossa, and the initial opening is extended towards the midline, down to the pyriform incisure (Fig. 75). After

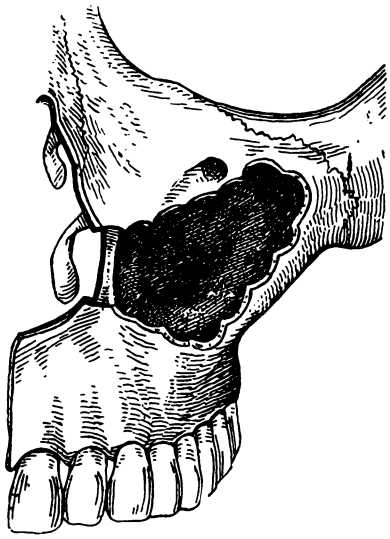


Fig. 75. Trephination hole in Denker's operation upon removal of the entire anterior wall of the maxillary sinus, including the apertura piriformis

the frontal wall has been cut open Luer's forceps and a gouge are used to remove the medial wall of the sinus in the region of the inferior nasal meatus. It is important to smooth out prominences for planting and rapid healing of the flap cut out of the mucous membrane of the lateral nasal wall, as well as for subsequent irrigation therapy. The square flap should be of adequate size and attached by its base to the nasal floor to permit its being grafted to the floor of the maxillary sinus and secured with tampons. The operation is rounded off with suturing the oral wound. The tampon is removed from the nose on the second day and from the maxillary sinus on the fourth day after the operation; the stitches are removed simultaneously with the latter procedure. The postoperative treatment is by syringing the sinus through the nose and the newly-formed anastomosis. The apprehensions voiced by a few authors concerning a possible saddle-nose deformity as a result of the removal of the crista piriformis have proved groundless. The postoperative complications are the same as after Caldwell-Luc operation.

Choice of method. In empyema of the maxillary sinus its complete drainage is ensured by Caldwell-Luc operation. Denker's operation is required only for malignant tumours and osteomata. The drainage of maxillary sinus empyema complicated by inflammation of the orbital cellular tissue, particularly with changes in the bony orbital walls, is implemented by N. N. Bogoyavlensky's method, which will be described below.

2. Operations on the Frontal Sinus

All of the existing methods of external surgical approach to the opening of the frontal sinus may be subdivided into the following four groups.

Methods of External Operations on the Frontal Sinus

Facial Methods	Orbital Methods	Fronto-Orbital Methods	Supra-Orbital Methods
1. Partial resection of the facial wall (Ogston-Luc, 1884-94).	1. Complete resection of the orbital wall (Jansen-Ritter, 1893-96).	1. Complete resection of the facial and orbital walls with removal of the supra-orbital margin (Ridell, 1898).	1. A. N. Lyubomudrov's method (1924).
2. Complete resection of the facial wall (Kuhnt, 1884) and extended Kuhnt's operation (Uffenorde's modification).	2. Transorbital operation after N. N. Bogoyavlensky.	2. The same operation with retention of the horizontal supra-orbital osteoperiosteal bridge (Killian, 1902).	2. Transaperture-frontal opening after N. V. Belogolovov (1926).
3. Temporary resection of the facial wall (S. S. Golovin's osteoplasty, 1897) and extended operation after S. S. Golovin; 1922.		3. Y. N. Malyutin's method (1910).	

Fig. 76 (*a*, *b*, *c*) gives a semi-schematic view of the features peculiar to orbital and fronto-orbital opening of the frontal sinus.

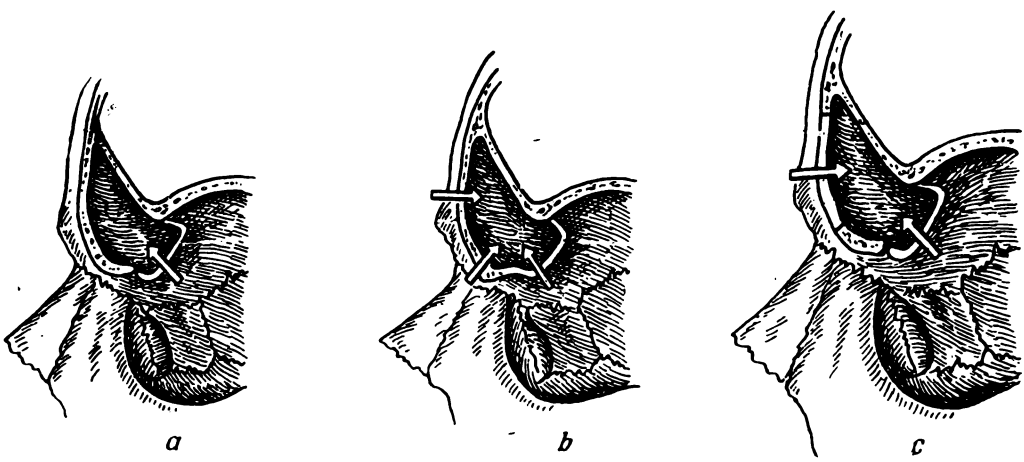


Fig. 76. The sagittal cross-section of the frontal sinus for illustrating the surgical approach in orbital and fronto-orbital methods of opening the frontal sinus (semi-schematic view). Arrows show the bone defect formed in surgical interference

a — Jansen-Ritter method; *b* — Ridell's method; *c* — Killian's method

Facial Methods

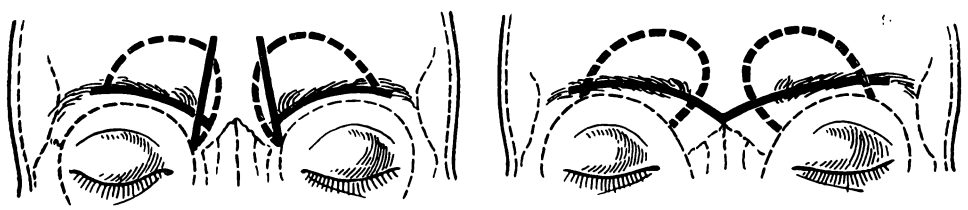
The facial methods of Ogston-Luc and Kuhnt are today out of use.

S. S. Golovin's osteoplastic method (Figs. 77*A* and *B*), which consists in a temporary resection of the facial wall of the frontal sinus, was inadequate in its initial version (1897) for opening and cleansing the ethmoid labyrinth, which is nearly always involved in the morbid process simultaneously with the frontal sinus; certain improvements were therefore introduced into it by S. S. Golovin. In its final form the new variant of S. S. Golovin's extended operation was described in 1922 by A. S. Golovina. The final modification essentially consists, according to A. S. Golovina, in that, following the opening of the frontal sinus, "wide and energetic manipulations are made with a sharp curette to open extensively the cells of the ethmoid labyrinth; in this way the latter may be opened without additional incisions in the lateral nasal wall, and the fronto-nasal region together with the ethmoid labyrinth are thrown into one wide operative cavity".

Orbital Methods

Jansen-Ritter method (1893-96) has been to date the most widespread and effective method of opening the frontal sinus and the ethmoid labyrinth, particularly for orbital complications; it is likewise indicated for a low but deep sinus. A specific feature of this method is the opening of the sinus via the orbit (Jansen), and Ritter's modification (1896) permits to use it also for high sinuses. This modification essentially consists in that, in addition to removal of the floor of the frontal sinus, a small opening is formed at an oblique angle at the upper margin of its anterior wall, through which to examine and scrape off the sinus contents.

The operative techniques. The incision is made along the brow, starting from its outer and ending at its inner boundary, and carried down in an arched line along the lateral nasal wall to the nasolabial fold, which corresponds to the upper margin of the apertura



A *B*

Fig. 77. The lines of incision in S. S. Golovin's osteoplastic opening of the frontal sinus. The continuous line is the skin incision; the dotted line shows the incision of the periosteum and the size of the resected part of the sinus wall

a — unilateral opening; *b* — simultaneous opening of both sinuses

piriformis. An incision is made in the soft tissues and periosteum, as well as in the internal palpebral ligament. The separation of the soft tissues with the periosteum brings the lacrimal sac cupola and lacrimal fossa into full view, while the orbit, or rather the tarso-orbital fascia, is not opened. Guided by these landmarks trephination is made at the supero-internal angle of the orbit, i.e., the portion where the frontal and lacrimal bones form a juncture with the frontal process of the maxilla. A probe is slipped into the frontal sinus through the hole made in the bone in order to determine its size in the vertical and particularly in the antero-posterior aspects. Hajek-Claus' forceps or a gouge is used to expand the bone opening until complete destruction of the frontal sinus floor (Fig. 78). In case of a bone defect caused by eruption of an empyema the surgeon's task is simplified, but to avoid relapses he should carefully cleanse all the cells, for instance, the retrobulbar cells of the ethmoid labyrinth, destory all partitions and smooth out rough spots to throw the frontal sinus and the orbit into a single wide cavity. The entire mucous membrane, particularly that affected by polypous degeneration, should be scraped off with a curette or Brünings' forceps. To reach into the ethmoid labyrinth one should destroy the papyraceous lamina, partially remove the frontal process of the maxillary bone, as well as the nasal and lacrimal bones. The ethmoid labyrinth should be scraped out with a curette; under no circumstances, however, should its sharp edges be turned upwards for fear of damaging the cribriform plate. A broad communication with the nasal cavity is provided by resection of the frontal process of the maxillary bone. The original method of Jansen-Ritter does not provide for a flap to be cut out of the nasal mucosa for promoting the epithelisation of the new anastomosis. Uffenorde, Barany, Halle and others insist on the use of plastic surgery in view of the danger of stricture and even atresia of the newly-formed anastomosis. To prevent stricture a rubber tube is introduced into the sinus through the nose with openings cut out all along its length; the tube is fastened at the nasal wing and allowed to remain 8 to 10 days. The external nose should be lubricated with liquid petrolatum to facilitate the withdrawal of the tube; in order to prevent crusting and obstruction of its lumen, the tube is daily filled with liquid petrolatum. The wound is sutured tightly, and the stitches are removed in 5 to 7 days' time.

The disadvantage of this method, i.e., brief diplopia following the detachment of the trochlea is exaggerated by many authors. To prevent diplopia Halle recommends an arched skin incision below rather than along the brow; in case of postoperative diplopia persisting for one or two years he suggests his method of repeated operation to be used to keep the trochlea in place. Since it is not always possible to preserve the trochlea in removing the frontal process of the maxilla, Halle recommends to survey the wound and try to shift the orbital contents to their normal place. This

is achieved by passing catgut sutures between the periosteum of the orbital boundary and the periorbit and tightening them up only after the patient is found to have no double vision in any direction. Following this the periosteum and periorbit are sutured all along their length, matress and knotted stitches being applied to the skin and covered with a facial dressing fixed with a plaster.

According to Birch-Hirschfeld, diplopia is averted by incising the periosteum around the trochlea and retaining only a few millimetres wide strip, whereupon the trochlea is separated by use of a gouge together with the lamina of the underlying bone. This results in the trochlea being better adjusted in its proper place in subsequent healing (quoted from S. S. Golovin). S. S. Golovin recommends the application of catgut sutures to the periosteum following an operation.

N. N. Bogoyavlensky's transorbital method. This method of opening the paranasal sinuses is regarded by its author as a standard-type surgical interference. The principal indication for opening the paranasal sinuses is the presence of gunshot wounds with foreign bodies wedged in one of the sinuses or an orbit. This operation should also be employed for retrobulbar phlegmons of rhinogenous origin as well as for tumours of the orbito-sinual region. N. N. Bogoyavlensky considers that his method of operating for phlegmons should replace Krönlein's operation.

N. N. Bogoyavlensky's operation is performed under local anesthesia induced by subperiosteal injection of a 1 per cent novocaine solution to a depth of some 3 cm into the orbit.

The operative techniques. An incision is made along the brow and nasal dorsum, and carried down to the bone. A narrow raspatory is used to separate the periosteum to the required depth from the orbital roof and medial wall or from the orbital floor, as in an operation on the maxillary sinus. A blunt hook is used to draw the orbital contents along with the eye outwards from the sinus to be opened. Thus, when opening the ethmoid labyrinth Thiss' gouge is used to cut through the papyraceous lamina. The anterior and posterior ethmoid cells are opened with a gouge or a curette, a drain tube is inserted into the nasal cavity, and the operative cavity is stitched up. Upon removal of the posterior ethmoid cells the transorbital ethmoidotomy may be supplemented by the opening of the sphenoid sinus with the Thiss or Voyachek gouge.

The frontal sinus is opened through the orbital roof, while the maxillary sinus is reached through the orbital floor and drained through the nose.

Fronto-Orbital Methods

These methods of surgical opening of the frontal sinus and ethmoid labyrinth are rarely used today, but should be made known to the ophthalmologists to facilitate training in more compli-

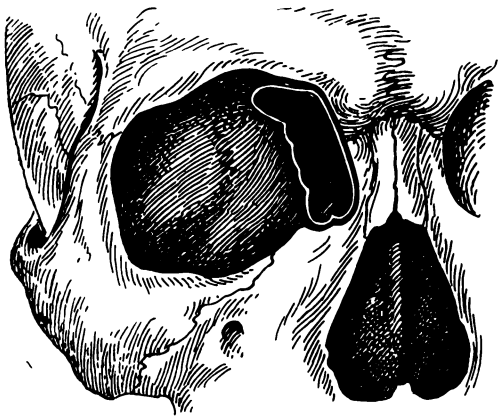


Fig. 78. Trephination hole in Jansen-Ritter operation

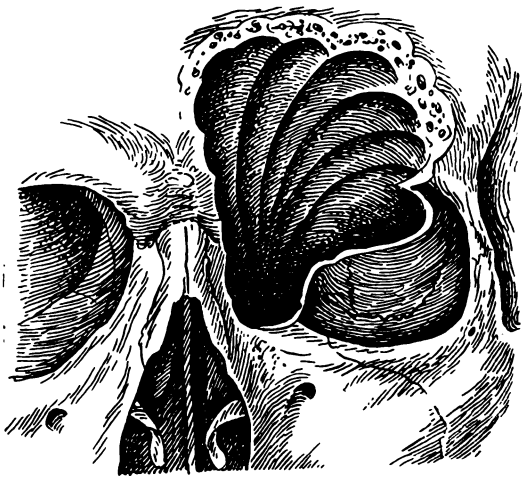


Fig. 79. A view of the opened frontal sinuses and ethmoid labyrinth in Ridell's operation

cated operative interventions, such as extraorbital exenteration of the orbito-sinual region, of which Ridell's operation is the first stage.

Ridell's operation (1898) is used in the case of a shallow frontal sinus for its obliteration by complete removal of its facial and orbital walls (Figs. 76*b* and 79).

The operative techniques. The incision in the skin and periosteum is made along the brow and the slope of the nasal dorsum. Following the removal of the anterior and inferior walls of the sinus, its mucous lining is scraped off, and the frontal process of the maxilla is resected to provide a broad access to the ethmoid labyrinth. The cleansing is made by means of a sharp curette. Should the operation be made in a subject with a shallow sinus, no facial deformity will follow the sinking of part of the forehead region, since the soft tissues are propped up by the closely located posterior wall of the sinus. In the case of a deep sinus this operation results in an ugly facial deformity, and preference, therefore, should be given to Killian's operation.

Ridell's operation is mainly used for gunshot wounds causing osteomyelitis of the anterior orbital wall and for orbital compications.

Killian's method (1902). The principal characteristic of this method is removal of the anterior and inferior walls of the sinus; to avoid deformation following the sagging of soft tissues, a periosteo-osseous bridge is preserved along the supraorbital ridge (Fig. 76).

In order that the lips of the wound may be accurately adjusted for suturing, notches are cut in the epidermis transversely to the horizontal incision to be made. The skin incision is carried down

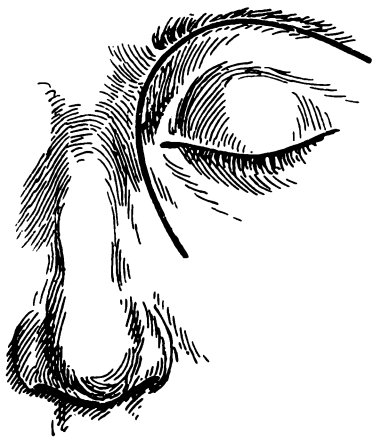


Fig. 80. Killian's arched incision in an operation on the frontal sinus (fronto-orbital method)

Fig. 81. The superior and inferior periosteal incisions in Killian's operation

to the periosteum along the brow and to the nasal root, from where it is continued in an arched line down the slope of the nasal dorsum to the very naso-labial fold (Killian's incision; Fig. 80). The soft tissue covering the periosteum is thereupon separated, and elevated 1 to 1.5 cm to expose the entire anterior wall of the frontal sinus. The bony bridge along the supraorbital ridge, 0.5 cm wide, together with the periosteum supplying its trophic requirements is formed by two parallel incisions of the periosteum. The upper incision is made half-a-centimetre from the supraorbital ridge and continued parallel to the inferior incision (Fig. 81); the latter corresponds to the skin incision and is begun from the supraorbital notch and carried to the middle of the frontal process of the maxilla.

Following the elevation of the periosteum and removal of the anterior wall of the frontal sinus situated above the upper boundary of the newly-formed bridge, a resection is started of the frontal sinus floor, i.e., the orbital roof, either through the frontal sinus or through the orbit. This is attained by removal of the frontal process of the superior maxillary bone, the upper pole of the lacrimal bone and part of the frontal bone, down to the intero-inferior portion of the bony bridge. This having been made, it is easy to remove the ethmoid cells and provide a broad communication between the frontal sinus and the nose. To avoid injury to the place of attachment of the superior obliquus muscle, it is advisable to elevate the periosteum only in the inner third of the orbital boundary. The pathologically changed mucous membrane is scraped away with a sharp curette, particular caution being displayed with regard to the posterior wall of the frontal sinus. A flap attached by its lower side is cut from the nasal mucosa and placed in the newly-formed anastomosis of the frontal sinus with

the nasal cavity, where it is secured with a tampon or a rubber drain passed through the nose; the end of the rubber drain is sutured to the nasal wing. The stitches applied to the wound are removed within 5 or 6 days of the operation, and the rubber drain within 9 or 10 days.

Y. N. Malyutin's method is a modification of Killian's operation meant to obviate a few of the latter's drawbacks, such as sinking of the soft tissues of the supraorbital region, necrosis of the bony bridge, diplopia, stricture of the naso-frontal duct, etc. The principal distinction of this method is resection of not only the anterior wall of the sinus but also of the naso-frontal duct whereby both are made an open cavity facing outwards, through which to open the ethmoid labyrinth.

Supraorbital Methods

A. N. Lyubomudrov's method (1924) has been developed from the suggestions made by M. F. Tsytovich, Y. N. Malyutin and M. A. Samoilenko. Its basic principle is a highly sparing approach to the anterior wall and floor of the orbit, the papyraceous lamina, and a special procedure employed for the ethmoid labyrinth (according to Y. N. Malyutin).

N. V. Belogolovov's method (1926). The basic characteristic of this operation is the opening of the frontal sinus through the apertura piriformis along the route coinciding with that of Halle's endonasal operation, as though it were conducted externally, i.e., under the guidance of vision. In the opinion of the author and his associate P. L. Manuilov this operation not only permits exposure of the frontal sinus to a wide examination and resection of the cells of the ethmoid labyrinth but also provision of a broad anastomosis with the nose. This operation involves no risk of facial deformity.

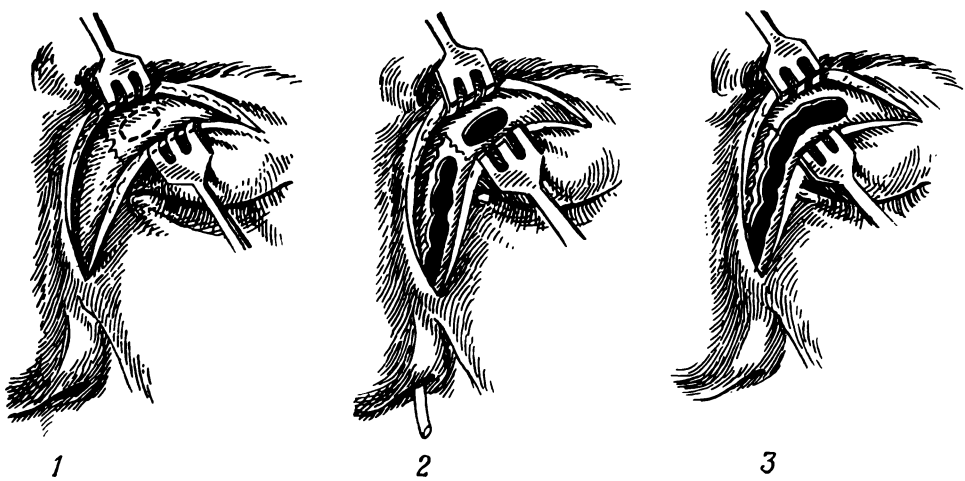


Fig. 82. N. V. Belogolovov's method
1 — landmarks and the site of trial trephination; *2* — formation of the bony channel and bridge (Ridell's layer); *3* — the bone wound in its final shape

The operative techniques. The operation should be preceded by an endonasal removal of the anterior end of the middle nasal turbinate. A crook-shaped incision (Fig. 82, *1*, *2*, *3*), its handle skirting above the suture between the nasal and frontal bones, is made down to the bone, continued along the lower boundary of the inner third of the brow and carried down the slope of the nasal dorsum, to the edge of the pyriform incisure or somewhat outwardly to it, i.e., along the frontal process of the maxilla. The soft tissues with the periosteum are elevated extensively until the junction of the frontal process of the maxilla with the nasal and frontal bones have been exposed, as well as the initial portion of the nasolacrimal duct, the anterior portion of the papyraceous lamina and the frontal spine. This is where the sinus should be opened, and pending this procedure it is probed in various directions to determine its size. Hajek-Claus' rongeur forceps are then used to widen the opening into what will look like a channel passing along the supraorbital ridge, the anterior and inferior walls of the sinus being preserved to avoid facial deformity. In the direction of the nose, the opening is widened down to the suture between the frontal bone and the frontal process of the maxilla, where the outlet of the frontal sinus lies and the naso-frontal duct has its origin. The bone layer is very thick here, and is known as Ridell's layer. The frontal sinus is next operated upon, in which the polypously degenerated mucous membrane, all diverticula, septa, partitions, etc., are removed. The opening of the naso-frontal region is made from the side of the pyriform incisure, i.e., from below upwards. The bone at the outer boundary of the apertura piriformis is first seized with the forceps and destroyed, whereupon a channel is cut from below upwards, from the nasal mucosa to the bony bridge in Ridell's bony layer. When cutting the channel, precautions must be taken against lateral deviations for fear of damaging the papyraceous lamina and nasolacrimal duct; this is followed by providing a communication between the frontal sinus and the newly-formed channel. The nasal cavity is opened next, for which the subperiosteo-mucous layer is incised, the lips of the wound are drawn apart and fastened by means of Kocher's forceps. The final stage of the operation is the cleansing of the ethmoid labyrinth. A rubber tube is passed into the frontal sinus through the nose to support the mucosal flap extended from the nasal cavity. These plastics are intended to promote epithelisation of the anastomosis and formation of a stable naso-frontal duct. The lower end of the tube is fastened to the nasal wing, the wound sutured tightly and the drain allowed to remain 6 to 7 days, whereupon it is periodically replaced with a fresh drain for 2 or 3 days at a time until a stable anastomosis forms, usually in one to two months' time, which can be identified by rhinoscopy. The drain is shifted up and down daily to facilitate its subsequent withdrawal, and filled with liquid petrolatum. It should be noted

that anatomical studies made by L. I. Baranova at the clinic directed by Prof. B. S. Preobrazhensky have proved that N. V. Belogolovov's and Halle's operations have little in common, since the former removes only the lateral portion of the fronto-nasal region for forming the naso-frontal communication, whereas Halle removes this region altogether.

An advantageous feature of the supraorbital operations is the sparing approach to the orbital tissues, trochlea and nasolacrimal duct, inasmuch as the operative field lies outside the orbit. Unfortunately, in the presence of severe orbital complications of rhinogenous origin, such as a phlegmon, when the opening of the orbit is indispensable, the methods of A. N. Lyubomudrov, Y. N. Belogolovov, and others are unsuitable, and N. N. Bogoyavlensky's and Jansen-Ritter's operations are primarily indicated.

3. The Opening of the Ethmoid Labyrinth

Isolated lesions of the ethmoid labyrinth are infrequent; they are commonly combined with simultaneous lesions of the frontal sinus. The most acceptable method of opening the ethmoid cells is that suggested by the German ophthalmologist Kuhnt, which is based on an orbital approach.

The operative techniques. An arched incision is made along the supraorbital ridge, from the supraorbital notch to the nasolabial fold, and carried down to the bone. Within the operative wound the periosteum is elevated from the bone, care being taken not to injure the superior obliquus muscle of the eye. The lacrimal sac cupola having been exposed, it is extracted from its bony socket and drawn out and downwards, following which a blunt hook is used to pull the orbital contents outwards and thus reach the internal orbital wall. The landmark is the neuro-vascular bundle of the anterior ethmoid arteries and nerves transmitted by the ethmoid foramina. To avoid injury to the cranial contents the trephination of the papyraceous lamina should be made somewhat below the neuro-muscular bundle. A bony opening sized 2 by 3 cm is cut in the portion limited above by the suture between the papyraceous lamina of the ethmoid bone and the frontal bone and below by the suture between the ethmoid, superior maxillary and sphenoid bones. Resection should be applied to the papyraceous lamina, the lacrimal bone and in certain cases to the frontal process of the maxilla. A broad communication between the ethmoid labyrinth and the nasal cavity is provided by complete destruction of the intercellular partitions and removal of granulations and polyps. The operative wound may be as deep as 7 to 8 cm; particular caution should be displayed in its upper portion, in the vicinity of the cribriform plate, care being taken to keep the sharp edges of the curette turned down. Kuhnt's operation is indicated for all cases

of orbital complications, such as infiltration of soft tissues in periostitis, abscesses, phlegmons and fistulas.

Grünwald and Killian's method is identical in principle to Kuhnt's operation, the same, though shorter, incision being made as in the operation on the frontal sinus. Since, however, lesions of the ethmoid labyrinth are commonly encountered in combination with those of the other sinuses the labyrinth is usually opened through other sinuses, already exposed.

N. N. Bogoyavlensky's transorbital operation has been described above. It should be emphasised that his method enables approach to the posterior ethmoid cells without damage to the anterior cells. This approach is ensured by the appropriate incision being made along the medial orbital boundary, elevation and outward displacement of the soft tissues with the periosteum as well as the eyeball through the papyraceous lamina.

Thus, for a combined lesion of the maxillary sinus and the ethmoid labyrinth the most effective is the Jansen-Winckler operation with amendments made by Y. B. Preobrazhensky. Based on his anatomical studies, these amendments consist essentially in the opening and cleansing of the ethmoid labyrinth through the supero-internal angle of the maxillary sinus, i.e., following its opening after Caldwell-Luc, with little or no injury to the medial wall of the ethmoid labyrinth. The anterior ethmoid cells are opened with a modified sharp curette bent at a 75° angle to the handle. Even after this the fronto-orbital cells and the bulla ethmoidalis are inaccessible, however, and can be opened, as Y. B. Preobrazhensky notes, only by means of an external operation.

4. The Opening of the Sphenoid Sinus

A lesion of the sphenoid sinus is rarely encountered as an independent disease. The sinus is freed from its pathological contents through the initially affected and preliminarily opened sinus, for instance, the frontal sinus or the ethmoid labyrinth. In this connection the surgical treatment of the sphenoid sinus disease may take different forms. For a combined lesion of the frontal sinus, ethmoid labyrinth and sphenoid sinus Jansen-Ritter's, Bogoyavlensky's and Killian's methods are effective. For a disease of the sphenoid sinus concomitant with that of the maxillary sinus and the ethmoid labyrinth Jansen-Winckler's method is applicable, and for orbital complications Kuhnt's operation is indicated.

The opening of the sphenoid sinus is indicated both for simple and phlegmonous affections of the orbit and orbital contents, including those of the optic nerve, the immediate cause of which may lie in the sphenoid sinus.

For complicated lesions of the ethmoid labyrinth and the sphenoid sinus N. N. Bogoyavlensky's method is indicated.

B. THE OPENING OF THE ORBIT (ORBITOTOMY)

The term "orbitotomy" was coined by S. S. Golovin in 1904, and has been used in special literature ever since. As distinct from Birch-Hirschfeld who regarded orbitotomy as a method of incising soft tissues, S. S. Golovin implied not only the latter, which he referred to as "simple orbitotomy", but also the cutting of the bony orbital walls. He regarded simple orbitotomy as an independent operation, and as the initial procedure in Krönlein's operation or osteoplastic orbitotomy.

1. Simple Orbitotomy

There are different ways of approach to the orbit: it may be opened through the conjunctiva (orbitotomia transconjunctivalis), through the palpebral ligament or through the palpebral skin (orbitotomia transcutanea). The latter method, which provides for no resection of the bony orbital wall, is the most widespread.

The incision is made along the orbital margin, to which fact its name "marginal" is due; the eyelid is incised along its line of attachment to the orbital boundary, without opening the conjunctival sac.

If the incision in the soft tissue is not carried deeper than the periosteum, in which case we have supraperiosteal orbitotomy (orbitotomia marginalis extraperiostalis), the septum orbitae firmly attached to the orbital boundary and hampering the entry into the orbit should invariably be broken, thereby providing access to the cellular tissue and retrobulbar space, which is required for the extraction of tumours confined to this area.

The marginal incision was first suggested by S. S. Golovin in 1904; in 1907, Rollet made a similar suggestion and, since he had discovered an aponeurosis dividing the orbital contents from the periosteum, proposed to call the operation subaponeurotic or subfacial orbitotomy.

Confirming the existence of such an aponeurosis, S. S. Golovin expressed doubt that most tumours, as presumed by Rollet, originated in and were for a long time confined to this place exclusively. The reason for his doubts was his belief that the weak fascia could hardly resist the penetration of the tumour from the subaponeurotic space into the orbit. S. S. Golovin insisted, however, that this protective lamina should be left intact.

Where the marginal skin incision is carried down to the bone, while the tarso-orbital fascia—and consequently the orbital cavity—remains unopened and is elevated from the bone with a blunt raspatory, the operation may be called simple subperiosteal cutaneous orbitotomy. This operation is indicated for subperiosteal abscesses associated with paranasal sinus empyema, for periostitis, and for opening the frontal sinus and the ethmoid labyrinth to

effect a cure for various diseases developing in these sinuses and extending towards the orbit.

Supraperiosteal orbitotomy is used for inflammations of the soft orbital tissues and for tumours; in the latter case it constitutes only the first stage of the operation. Unfortunately, it is not always possible to select in advance the required method of orbitotomy.

Orbitotomy may be superior, external, inferior or internal; and each of these methods has its own specific features depending on the topographical anatomy of the orbital boundaries.

Superior orbitotomy. In periosteal orbitotomy, which leaves the tarso-orbital fascia intact, the skin incision is made along the lower margin of the brow, and the periosteal incision somewhat above that level to achieve downward detachment of the tarso-orbital fascia together with the periosteum. The incision continues along the outer and middle third of the supraorbital margin, up to the supraorbital notch. When elongating the incision in the inner third of the supraorbital margin it becomes necessary to cut the surpaorbital nerve, though this leads to a prolonged loss of sensitivity of the forehead skin, lasting 3 to 5 months; there is also a risk of diplopia, since the trochlea displaced by separation of the soft tissues together with the periosteum does not heal after it has been set in its proper place at the end of the operation. These apprehensions, however, are not serious enough to give up the operation, and for the following reasons: (1) diplopia, as is proved by experience with intervention on the frontal sinuses, is not an inevitable complication; (2) its duration is in most cases brief (one or two weeks); (3) operative methods are available to prevent diplopia (Golovin, Halle, Birch-Hirschfeld).

External orbitotomy. A wide approach to the external wall and the adjacent regions of the superior and inferior walls of the orbit is provided by a large semi-circular incision made around the orbital opening. The separation of the periosteum in the region of the lacrimal gland should be made with caution to avoid its injury.

If there is no need for a broad approach to the external wall it may suffice to make a horizontal incision through the external ligament and separate the soft tissues upwards and downwards. The facial nerve branches supplying sensation to the eyelids are thereby kept intact.

Inferior orbitotomy. When making an incision along the infraorbital margin the inferior obliquus muscle attached to the inside surface of the orbital floor is liable to injury. The best way to avoid such injury is to separate the muscle along with the periosteum or the bony plate. Inferior orbitotomy may involve injury to the infraorbital nerve, which may be prevented by opening the nerve canal carefully and pulling the nerve aside with a blunt hook following its dislodgement.

Internal orbitotomy. The incision is made somewhat inwardly to the internal palpebral ligament, care being taken to avoid injury to the lacrimal sac. Even an incision and exposure of the edge of the supero-internal angle of the orbit alone will provide enough room for surgical interference. Should it be necessary to prolong the incision, the lacrimal sac is elevated with a blunt instrument along with the periosteum and drawn aside towards the temple.

2. *Osseous Orbitotomy*

Krönlein's method provides for an approach to the orbital contents through a temporarily resected external wall of the orbit. An indication for this operation is the confinement of the tumour primarily to the outer portion of the orbit.

The operative techniques. An arched skin incision, 6 to 8 cm long, its concave part facing posteriorly, as shown in Fig. 83, is started above, from the external portion of the frontal bone, on the border with the temporal region, and ended below, bending backwards, parallel to the zygomatic arch. In its most salient portion it passes anteriorly to the external orbital margin and somewhat posteriorly to the external palpebral ligament. The elevation of the periosteum is started in the middle of the incision, at the orbital margin, and extended upwards beyond the fronto-malar suture, downwards to the infraorbital fissure, and backwards from the spheno-malar suture. After the contents of the orbit together with the periosteum have been drawn outwards, a bony wedge is cut out of its external wall. The wedge, whose base is at the outer orbital boundary and the apex in the middle of the infraorbital fissure, is formed in the following way: a flat, thin and sharp gouge is used at first to separate the zygomatic process at the line of its attachment to the frontal bone, and the latter is then incised along a straight line passing obliquely downwards, from the separated process to the infraorbital fissure. Following this the frontal process of the malar bone and the bone itself are cut from the above-mentioned portion to the orbital fissure.

The wedge-shaped bony plate thus formed is turned outwards together with the soft tissues, i.e., a flap made up of cutaneous, fascial, muscular, subperiosteal and osseous tissue.

To make the orbital contents accessible to examination, and, should need arise, to surgical treatment, the exposed periosteum is cut with blunt scissors in a horizontal direction, along the external rectus muscle, and the lips of the wound are drawn apart with retractors.

If there is need to cut the external rectus muscle, it is incised at its scleral end and after catgut sutures have been applied on both sides of the future incision, so that it can be stitched up when the

operation is over. The operation is completed by reposition of the resected bony wedge.

S. S. Golovin's method. In this procedure, the elevation of periosteum and incision of the external rectus muscle, as provided for in Krönlein's operation, are not employed.

The first stage of the operation is simple orbitotomy along the external wall, temporary resection of the external orbital wall being undertaken only if the tumour has been found to be located at the roof of the orbit and more space is required for examination of the entire region or excision of the tumour.

The operative techniques. The skin incision, forked or round (Fig. 84), is started from a point 1 to 1.5 cm outside the external orbital boundary. The upper portion of the incision passes along the lower margin of the brow, and the lower one along the infraorbital boundary. Depending on the requirements, the incision may be extended thus: along the brow—to its inner end, and along the infraorbital margin—to the inner angle of the orbit, in order to facilitate approach to various portions of the orbit. The first stage of the operation ends with exposure of the external orbital margin, section of the external palpebral ligament, and opening of the tarso-orbital fascia. The second stage consists in a temporary resection of the external orbital wall together with the periosteum. The author gives no details of this stage, since it is apparently identical to Krönlein's method. Following the resection of the external wall and incision of Rollet's aponeurotic layer, which are made parallel to and above the external rectus muscle, the widest possible approach to the orbit is obtained. When the operation is over,

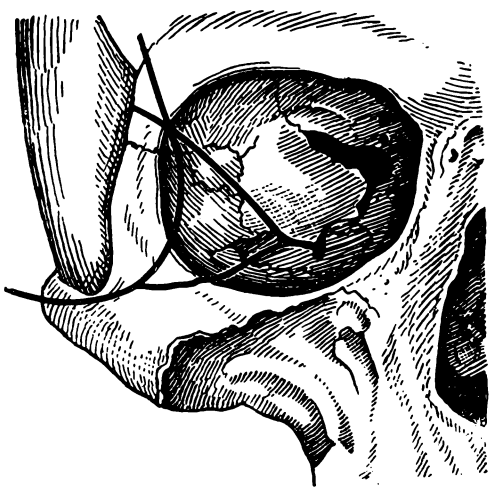


Fig. 83. The lines of incisions in Krönlein's operation

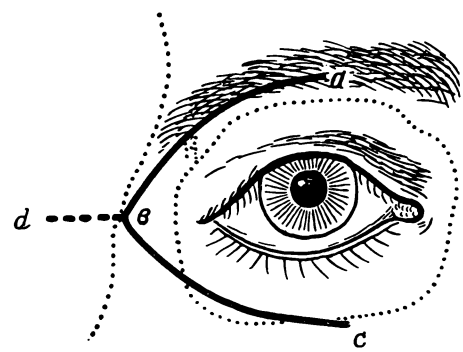


Fig. 84. The lines of incisions in S. S. Golovin's osseous orbitotomy (modified Krönlein's operation)

the temporarily resected external wall is set back in place, and the skin wound is closed with a subcuticular suture. In some cases the external wall has to be fastened during reposition with catgut stitches passed through the periosteum. The author of the method recommends caution in separating the tissues to avoid injury to the superior palpebral levator. To prevent eye injury at operation and sores of the cornea due to compression by the dressing, S. S. Golovin advised application of stitches to the palpebral fissure temporarily, for 5 to 6 days, at the beginning or after the operation.

Selection of method. Among the disadvantages of Krönlein's method is the need for elevating the periosteum, while cases are known to clinicians where bone resection has proved superfluous. Moreover, the periosteum, elevated together with the orbital contents, serves to decrease the operative field and interferes with orientation.

An incision at the external orbital margin is advisable where the tumour is located in another portion of the orbit, particularly at the internal wall, as well as for inflammations caused by a primary lesion of the paranasal sinuses.

After additional cuts in the skin, incisions made after Krönlein leave ugly scars; another shortcoming is the need for cutting the external rectus muscle.

By comparison, S. S. Golovin's method has a number of advantages, which are as follows: (1) a good cosmetic effect, inasmuch as the scars from healed incisions are hidden within the natural folds of the skin and in the eyebrow; (2) no need for bone resection; (3) preservation of the external rectus muscle; (4) the possibility of extracting the tumour not only from the external but from any portion of the orbit; (5) the possibility "of employing such procedures as can be immediately adjusted to changes in the situation, making the operation flexible and enabling the surgeon to cope with unexpected developments" (S. S. Golovin).

During World War II, N. N. Bogoyavlensky's transorbital approach to the paranasal sinuses proved the most effective for removal of orbital tumours and completely superseded Krönlein's method.

C. TYPES OF COMBINED OPERATIONS PERFORMED SIMULTANEOUSLY ON THE ORBIT AND PARANASAL SINUSES

S. S. Golovin's operation, i.e., combined exenteration of the orbit and the adjacent sinuses, consists in throwing them into one wide bowl-shaped and skeletonised cavity perfectly accessible to examination and cleansing. This is achieved by breaking down partitions between the sinuses and the orbit and destroying crypt-

like pockets in the sinuses proper. The presence of a single cavity facilitates a radical removal of the tumour and promotes healing.

The operative techniques. The operation is performed by four stages: (1) the making of incisions circumscribing the tumour and the cutting-out of the musculo-cutaneous flaps for plastic closure of the defect (Fig. 85); (2) subperiosteal exenteration of the orbit, preferably in one piece; (3) the opening and cleansing of the paranasal sinuses; (4) closure of the defect by shifting the musculo-cutaneous flaps from the forehead and cheek (Fig. 86).

Two vertical and two horizontal incisions are made in the following manner. The first—internal and vertical—incision (Fig. 85*a*, *b*) is started 2 to 3 cm above the glabella along the midline of the forehead, continued downwards along the medial margin of the orbit on the lateral side of the nasolabial fold, and ended 1 cm below the nasal wing; the second—external and vertical—incision (Fig. 85*c*, *d*) of a somewhat smaller size is made parallel to the first; beginning from the outer angle of the orbit it passes downwards along its lateral margin and on the cheek, and crosses the zygomatic arch 1 to 2 cm beneath. The superior horizontal incision is made along the superciliary ridge, connecting both vertical incisions (Fig. 85*e*, *f*); the inferior horizontal incision (Fig. 85*g*, *h*) parallel to the former also connects both vertical incisions and passes somewhat below the infraorbital margin. The incisions are shaped like the letter "H" with two cross-lines.

The musculo-cutaneous flaps in the region of the forehead and cheek are separated upwardly all along the length of the forehead, and downwardly to the alveolar process, whereupon the forehead flap is drawn up and the cheek flap down.

Following exenteration, the orbital cavity is thrown into a wide communication with the paranasal sinuses harbouring the tumour.

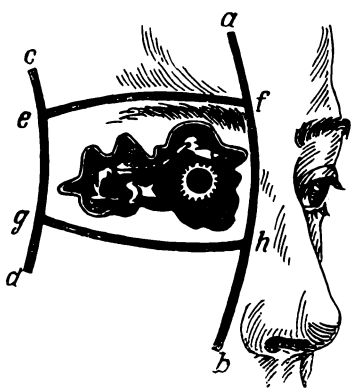


Fig. 85. The lines of incisions in S. S. Golovin's combined exenteration of the orbit and paranasal sinuses

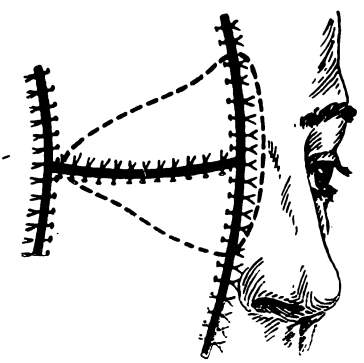


Fig. 86. Suturing of the skin lips of the wound after S. S. Golovin

As is known, its most frequent site is the maxillary sinus or the ethmoid labyrinth. The common cavity is formed by destroying the anterior, medial and orbital walls of the maxillary sinus, the frontal process of the maxilla, the lacrimal bone, the papyraceous lamina of the ethmoid bone, a portion of the nasal bone and the nasal process of the frontal bone. All the partitions of the ethmoid labyrinth and its lateral wall, as well as the nasal turbinates in the nasal cavity are subject to destruction. The resection of the bony walls is performed with a gouge, Hajek-Claus' forceps and osteotomy scissors, while the mucous membrane is scraped off with a broad curette. The frontal and sphenoid sinuses are opened if the appropriate indications are present. The portions bordering on the tumour and those suspected of affection are electrocoagulated. After the edges of the upper and lower flaps have been approximated and stitched with knotted sutures the junction of the incisions takes the form of the letter "H" with one cross-line.

The following is a report on our observation of a patient who was subjected to exenteration of the orbit combined with opening the right-side maxillary sinus and the ethmoid labyrinth for a relapsing malignant tumour.

Case report 24. Patient S., female, aged 75, hospitalised on August 24, 1950, for relapsing right-side orbital tumour (tumour recidivum orbitae dextrae).

Neurectomy on the right side in 1931 for malignant tumour discovered in histological examination. In 1944 tumour recidivated, patient refused operation. Physical examination of the right eye: orbit abnormally large, eyelids dilated and swollen, palpebral fissure widely open; projection and tuberous tumour, the size of a chicken egg, hard on palpation and pervaded by vessels found between eyelids. Left eye normal.

An X-ray examination showed a considerable enlargement of the right orbit, its walls, particularly the inferior (partially) and the external, being atrophied. The orbit and the right maxillary sinus were shadowed.

A right-side orbito-sinual exenteration (exenteratio orbitosinualis dextra) was undertaken with local anesthesia. A skin incision shaped like the letter "H" with two additional cross-lines was made in the orbital region, as shown in Fig. 85, both vertical incisions being connected by two transverse cuts, one of which was drawn somewhat above the brow, the other somewhat below the infraorbital boundary. Following the incisions, separation and cutting-out of musculo-cutaneous flaps for plastic closure of the defect, the orbital contents were removed from under the periosteum. The internal and inferior walls of the orbit had been damaged. The ethmoid labyrinth was relieved from the tumour; the sphenoid sinus was opened and proved to be free from the newgrowth, which, however, was found to have invaded the maxillary sinus. After the stitches were applied healing followed by first intention. A histological examination of the tumour confirmed the diagnosis of melanocarcinoma.

V. P. Filatov's and N. K. Lysenkov's method of extraorbital exenteration of the orbit and paranasal sinuses. This operation, employed for diffuse orbital tumours of the orbit extending far beyond its limits, permits extraorbital interference and involves the least possible danger of injury likely to produce a relapse. This is achieved by combining the two stages of S. S. Golovin's operation: exenteration of the orbit and opening of the paranasal sinuses. The primary procedure is to open the paranasal sinuses, which is followed by extirpation of the tumour along with the walls and contents of the orbit.

The operative techniques. The preoperative procedures are as usual. The authors have used general anesthesia and tamponade of the choanae through the nasopharynx with the aid of a drainage tube or a catheter. Y. I. Alpin, employing the Filatov-Lysenkov's method, has induced anesthesia by instillation and injection of a 10 ml dose of a 1 per cent novocaine solution and an 80 ml dose of a 0.5 per cent novocaine solution, preceded by an intravenous administration of 1 ml of a 1 per cent morphine solution. I. M. Sobol also rejects general anesthesia for this operation. All of these authors believe that it is likewise unnecessary to use nasopharyngeal tamponade.

Similarly to S. S. Golovin's method, V. P. Filatov makes four incisions into the soft tissues, down to the bone (Fig. 87). (1) The superior horizontal incision passes along the supraorbital margin, from the external edge of the zygomatic process of the frontal bone to the inner end of the eyebrow. (2) The inferior horizontal incision is led along the infraorbital margin from the external edge of the frontal process of the malar bone to the middle of the lateral side of the nasal dorsum. (3) The internal vertical incision is passed from above downwards through the inner ends of the horizontal incisions, beginning from the forehead, at a point 2 to 3 cm above the end of the horizontal incision, and ending at

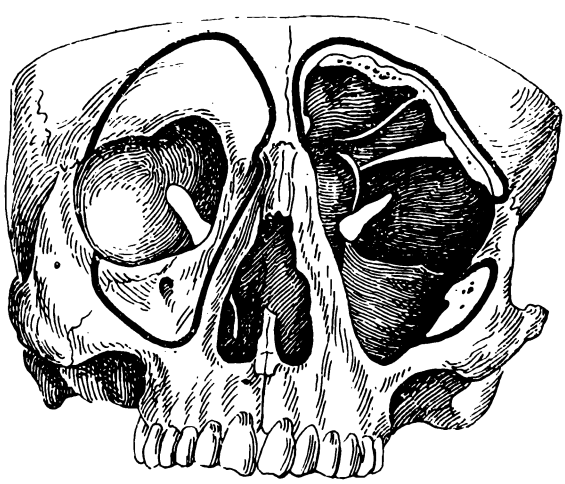


Fig. 87. The lines of incisions at right and the region of resection at left in Filatov-Lysenkov extraorbital exenteration of the orbit and paranasal sinuses

the nasal wing, 2 to 2.5 cm below the end of the inferior horizontal incision. (4) The external vertical incision is made through the outer ends of the horizontal incisions, beginning from the forehead, at a point lying 2 to 3 cm above the outer end of the superior horizontal incision and ending at a point 2.5 to 3 cm below the outer end of the inferior horizontal incision.

Depending on the size of the newgrowth, the horizontal incisions are made higher or lower than is described above, and the vertical incisions are made wider apart.

The soft tissues of the external portions are elevated and pushed aside from the orbital margins: to the frontal bone, to the nasal dorsum, and downwards—towards the alveolar process, etc.

At the same time the soft orbital tissues together with the periosteum are elevated from the external orbital wall to the inferior orbital fissure, from the superior orbital wall to its roof, and from the supero-internal portion—to the line "trochlea—foramen rotundum".

More recently, V. P. Filatov has drawn the conclusion that the soft tissues of the orbit should be elevated from the orbital roof at the third stage of the operation only after the frontal sinus has been opened and its size determined. Under this method the frontal sinus is opened first and its floor incised to provide access to the orbit and to separate the soft tissues from its roof. In this operation a larger portion of the orbital roof will be included in the osteo-orbital piece to be excised than under standard procedures, when the tissues are separated only up to the "trochlea—foramen rotundum" line.

The incision through the bones ought to be made in the appropriate sequence.

The tamponade, arrest of the hemorrhage and removal of suspicious tissues from the depth of the orbit and the opened paranasal sinuses, as well as the plastic closure of the defect with flaps are performed in the same manner as by S. S. Golovin. Fig. 88 presents a view of the operative field following a wide exenteration of the left orbit and opening of the left maxillary sinus, the frontal sinus and the ethmoid labyrinth for cancer, while Fig. 89 shows a photo of the patient following prosthetic repair (I. I. Merkulov's study).

B. A. Swartz's operation is a combination of a number of different methods. In his view, operations by stages provide an adequate approach to the paranasal sinuses and nasal cavity, and, if necessary, to the orbit as well to enable orbito-sinual exenteration after S. S. Golovin or V. P. Filatov and N. K. Lysenkov. The author maintains that his method permits successive and effective approach not only to the paranasal sinuses and nasopharynx, but also to the adjacent regions and makes it possible to narrow or expand the operative field, depending on the extension of the new-

Fig. 88. A view of the operative wound following extensive exenteration of the left orbit and opening of the left maxillary sinus, the frontal sinus and the ethmoid labyrinth for cancer

Fig. 89. The same case as in Fig. 88. A photo of the patient taken a few years later. The defect is concealed with a prosthesis fixed to a spectacles frame and covering the region of the left orbit

growth. In his opinion this method ensures freedom of action for the surgeon, who can alter the plan of the operation at his discretion.

The operative techniques. An incision is made in the soft tissues from the middle of the superciliary ridge through the lateral wall of the nose, continued to the upper lip and ended in the place of attachment of the nasal wing. The second incision is drawn parallel to the former through the soft tissues alongside the lower orbital boundary.

The soft tissues on both sides of the incisions are drawn apart with a raspatory to expose the nasal and lacrimal bones, the papyraceous lamina of the ethmoid bone, the frontal process of the superior maxilla and the edge of the apertura piriformis.

The resection of these bones and the internal wall of the maxillary sinus provides a broad and convenient approach to the nasal cavity and paranasal sinuses.

If the newgrowth or its shoots are found in the orbit, the basic incisions are lengthened from the middle of the superciliary ridge to the external margin of the orbit, and downwardly to the line of the inferior horizontal incision, so that the orbit may be isolated by cuts on all sides.

Moure's operation facilitates access to the superior portion of the nasal cavity, the ethmoid labyrinth, the orbit, the sphenoid and frontal sinuses, and even to the maxillary sinus.

The operative techniques. An incision in the skin and periosteum is made from the inner third of the brow, carried around the orbit along the lateral border of the nose and around the nasal wing to be ended on the upper lip at the nasal orifice (Fig. 90). For approach to the maxillary sinus, the incision is continued from the nasal hole to the midline, and then turned downwards to cut the upper lip. The elevation of soft tissues from the upper half of the apertura piriformis is followed by exposure of the frontal process of the maxilla, the nasal and lacrimal bones, as well as the nasal process of the frontal bone. The lacrimal sac is pushed out and downwards to avoid injury. Following the resection of the upper portion of the frontal process of the maxilla down to the apertura piriformis, as well as a part of the lacrimal bone, the papyraceous lamina of the ethmoid bone and the nasal bone, a wide approach is obtained for the removal of the malignant tumour from the paranasal sinuses and the orbit.

Denker's operation is a modification of the method of opening the maxillary sinus suggested by him in 1905. This operation, designed for excising malignant newgrowths primarily confined to the inferior portion of the nasal cavity and the maxillary sinus, as well as to the superior portion of the nose and the sphenoid

Fig. 90. Moure's incision in Uffenorde's modification for the surgical treatment of unilateral malignant tumours in the upper portions of the nose

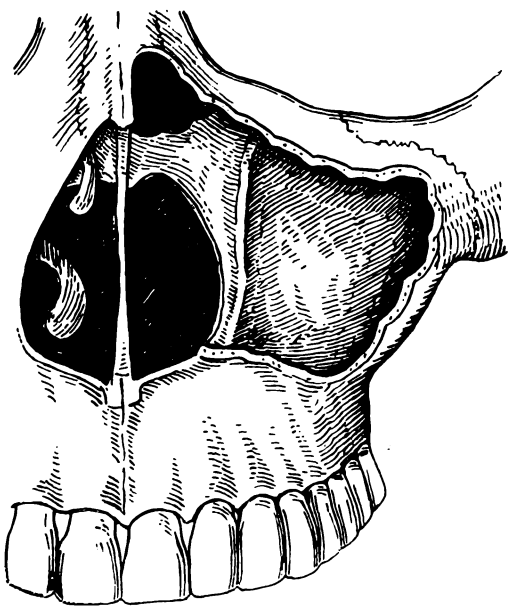


Fig. 91. Denker's method for removing malignant tumour from the nose, maxillary and sphenoid sinuses

sinus, involves the removal of the entire facial and medial walls of the maxillary sinus, the frontal process of the maxilla, i.e., the edge of the apertura piriformis on the appropriate side, and the inferior portion of the nasal bones (Fig. 91).

D. I. Zimont modified Denker's method by introducing an additional incision in the midline of the hard palate and alveolar process in order to split them in two. A leaf-shaped osteoplastic flap formed on the side of the affected maxillary sinus is turned downwards, i.e., into the oral cavity, to provide access to the inferior portion of the nasal cavity, nasopharynx and maxillary sinus.

Preysing's operation is one of the surgical procedures used for bilateral malignant newgrowths in the paranasal sinuses, mainly in the frontal sinuses and the orbits.

The operative techniques. A T-shaped skin incision is made, its horizontal part connecting the highest points of both superciliary ridges and the vertical part, perpendicular to the former, passing downwards along the nasal dorsum and ending 1.5 to 2 cm short of the tip of the nose (Fig. 92). Following the elevation of the soft tissues and separation of the lips of the wound, the entire exposed portion of the facial skeleton is removed, while preserving the edges of the apertura piriformis. Resection should be applied to both nasal bones, the adjoining parts of the frontal process of the maxilla, the lacrimal bones, both papyraceous laminae of the ethmoid bone, the anterior and inferior walls of both frontal sinuses, as well as the superior portion of the nasal septum.

Selection of method. Golovin's method of combined exenteration of the orbit and paranasal sinuses and the Filatov-Lysenkov's method of their extraorbital exenteration of the orbit and paranasal sinuses are intended for the removal of large malignant tumours extending from the orbit to the paranasal sinuses and vice versa.

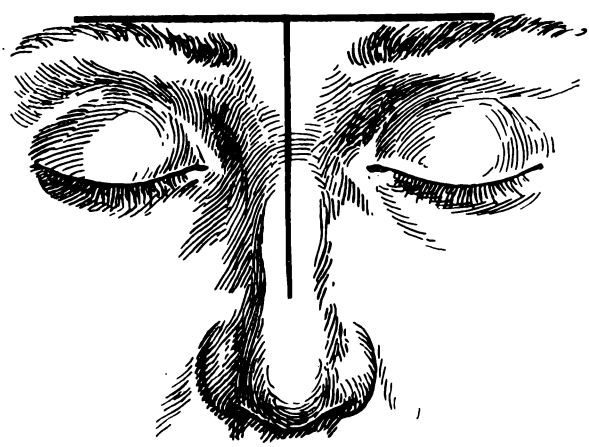


Fig. 92. The incisions in Preysing's operation for the removal of bilateral malignant tumours of the upper portions of the nose

For a newgrowth confined to the orbit and one of the paranasal sinuses S. S. Golovin's method is indicated. "It would certainly be an exaggeration," as V. P. Filatov himself put it, to use the extraorbital method he had developed in cooperation with N. K. Lysenkov. The extraorbital excision of the tumour is indicated for a tumour invading all the paranasal sinuses. In the opinion of L. O. Shpartko, who has collected material on 55 operations after the method of Filatov and Lysenkov, this method should be used for carcinoma rather than for sarcoma.

The advantage of the method, as has been shown above, is the possibility of ablastous interference, i.e., within healthy tissue, outside the tumour.

The Filatov-Lysenkov and B. A. Swartz methods are advantageous in that they make it possible to expand or narrow the operative field in relation to the extension of the morbid process.

Moure's and Denker's methods, while providing approach to the superior and inferior portions of the nose, the paranasal sinuses and the orbit, at the same time involve little hazard of injury.

D. OPERATIONS ON THE LACRIMAL SAC

The modern operations on the lacrimal sac are aimed at providing a communication between the lacrimal sac and the nasal cavity, and are divided into external and internal.

1. External Operations

Toti's method. Dacryocystorhinotomy is undertaken in order to restore tear drainage into the nose by providing a wide communication between the lacrimal sac and the nose to by-pass the obstructed nasolacrimal duct.

In 1904 the Italian rhinologist Toti suggested that the communication between the lacrimal sac and the nose should be formed from the outside, which came to be known as external or orbital rhinotomy. In Russia this operation was first performed by Prof. A. F. Shimanovsky in 1909 and described by S. I. Bogorad.

The operative techniques. A semi-lunar incision carried down to the bone is made 3 mm anteriorly to the internal palpebral ligament, 1.5 cm upwards and 2 cm downwards from it. The soft tissues with the periosteum are thereupon elevated up to the crista lacrimalis anterior, the flap thus formed containing an intact network of lacrimal passages. A broad opening into the nose is formed by resection with a gouge of the posterior portion of the frontal process together with the crista lacrimalis anterior, the antero-inferior part of the orbit, and the anterior portion of the lacrimal bone down to the crista lacrimalis posterior. After the edges of the bone defect have been smoothed out, a corresponding though somewhat smaller

opening is cut in the nasal mucosa, and the entire internal wall of the lacrimal sac is excised.

After the osseo-periosteal flap containing the external wall of the sac has been set in place, the skin wound is sutured. In cases of protrusion of the ethmoid cells or the middle nasal turbinate they should be removed, since their preservation would cause the opening to narrow. If the bony window into the nose is larger than that in the mucous membrane and the edges of the bony defect are smooth, there is full reason for confidence that the edges of the mucosal opening and those of the preserved wall on the lacrimal sac will be in close contact and subsequently accrete and no granulations will therefore obstruct the opening into the nose. Within 5 days of the operation a dressing is applied and control rhinoscopy is made, and two days later the sutures are removed from the skin wound.

A major disadvantage of this operation, when performed without applying sutures to the nasal mucosa and the sac wall in the hope that the wounded surfaces will heal by themselves, is closure of the opening by granulations.

Among the modifications of this operation, Dupuy-Dutemps' and Bourguet's methods suggested in 1921 drew the greatest number of supporters. Under the former method sutures are applied to the walls of the lacrimal sac and to the nasal mucosa, both cut in one lengthwise direction. In this way, the lacrimal sac is given a broad communication with the nose through what resembles a newly-formed diverticulum, which prevents the growth of granulations and obstruction of the outlet.

Under Ohm's method, however, the sutures are applied only to the anterior lip of the lacrimal sac and the nasal mucosa; in Ohm's view, the posterior lip requires no sutures, since the edges of the nasal mucosa and lacrimal sac usually adhere well to each other. For suturing the lips Ohm suggested needles of variable size similar to those used by rhinologists for resecting the nasal septum.

In the U.S.S.R., Dupuy-Dutemps' operation was first performed by M. I. Averbach in 1924. Below follows a description of this operation as it is performed at the Helmholtz Institute of Ophthalmology and the procedures of which have been reported by M. I. Averbach and Y. M. Ivanova.

Dupuy-Dutemps' method. Local anesthesia is induced 15 to 20 minutes before the operation with a 1 per cent novocaine solution in an 8 to 9 ml dose, half diluted with adrenalin in the proportion of 3 drops per 1 ml novocaine. The nose is packed with a tampon soaked in a 10 per cent cocaine solution with adrenalin.

The operative techniques. A 2 cm vertical incision slightly bent towards the nose is made in the skin and carried down to the bone, beginning from a point 2 to 3 cm above the lig. internum and 2 to 3 cm away from it. The incision resembles the inferior portion of Killian's incision in fronto-ethmoidal trephination. The wound

is dilated in the horizontal direction with Muller's speculum and in the vertical direction with Axenfeld's dilator. Following the arrest of hemorrhage, the periosteum together with the lig. internum and the sac is elevated from the bone with a raspatory to expose the bone in the region of the crista lacrimalis anterior and posterior of the frontal process of the maxilla and the lacrimal bone. A small grooved gouge and small forceps are thereupon used to remove bone tissue in thin shavings in the region of the frontal process and lacrimal bone until an oval opening is formed 1.5 to 2 cm in size along the vertical and 1 to 1.5 cm in size along the horizontal. Subsequently, the method of forming the opening, i.e., the communication, was modified at the Helmholtz Institute of Ophthalmology into what is described below (Y. M. Ivanova). Instead of removing bone tissue in small shavings it is excised in one piece, for which a grooved gouge is used to cut the bone along the borders of the prospective opening down to the nasal mucosa, whereupon the gouge is set in the inferior part of the crista lacrimalis anterior, nearly parallel to it, and tapped to dislodge the incised bone portion in the region of the frontal process of the maxilla and lacrimal bone, i.e., where the opening must be formed. The nasal mucosa along the entire length of the bony opening is incised with a thin pointed scalpel cutting vertically through the posterior and anterior lips. An identical longitudinal end-to-end incision is used to cut the lacrimal sac coated with periosteum. The sutures (according to Dupuy-Dutemps) are applied in the following manner: the posterior lips of the sac and nasal mucosa are stitched up, as are the anterior lips, and only in the event of a markedly distended sac is a small portion of its wall excised.

At the Helmholtz Institute of Ophthalmology sutures are applied in a somewhat different manner (M. I. Averbach). The posterior lips of both incisions are stitched up tightly with three catgut sutures. The sutures passed through the anterior lips are not tied up immediately, but are preliminarily passed through the lips of the skin wound in such a way as to have the thread from the nasal mucosa lead to the external lip of the skin wound and the thread from the mucous membrane of the sac to the internal lip of the wound. In this way these three sutures simultaneously connect the anterior lips of the nasal mucosa, the sac and the skin wound. The sutures applied to the posterior lips are left intact and subsequently resolve. The other sutures are removed in 7 days' time, and 2 to 3 additional stitches are applied to the skin. Figs. 93 and 94 present a schematic view of the operation and the suturing of the wound after M. I. Averbach.

When it is impossible to apply sutures to the mucous membranes by reason of flaccidness of tissue or bleeding, the latter are cut in the region of the opening and the corresponding portion of the internal wall of the sac is removed.

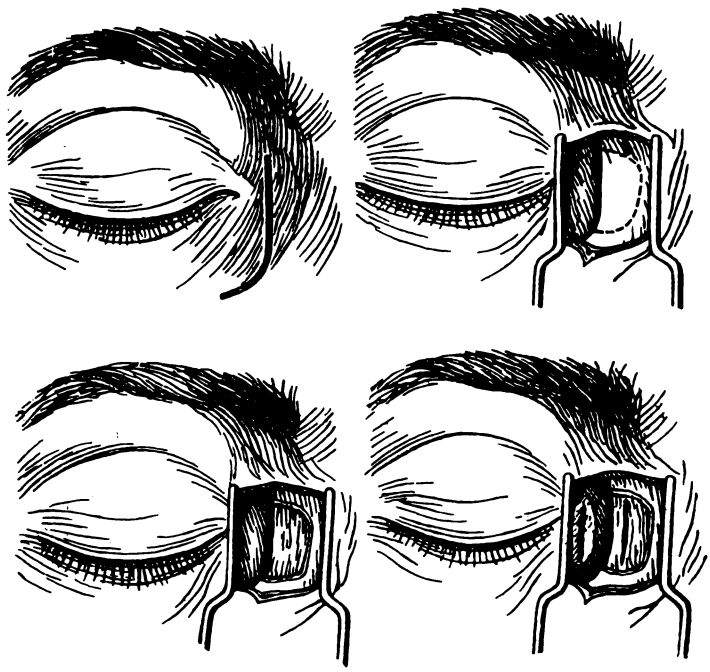


Fig. 93. The course of Dupuy-Dutemps' operation

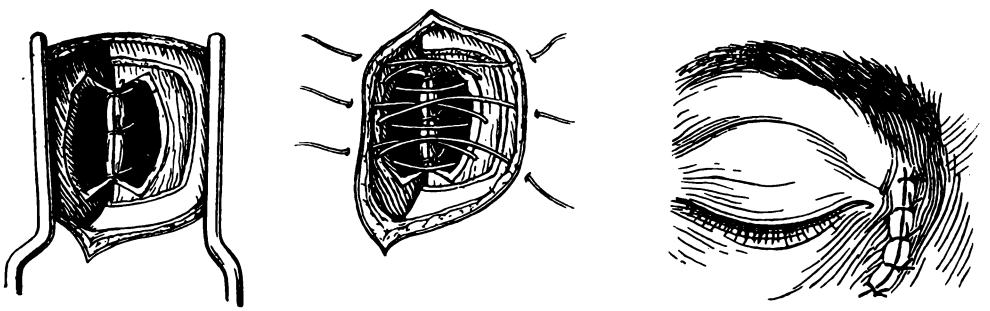


Fig. 94. Suturing the wound after M. I. Averbach

To avoid relapses M. I. Averbach has striven to make the entrance to the nasolacrimal duct as wide as possible to provide against the formation of diverticula in which secretion might become stagnant following the closure of the mucous membranes (Y. M. Ivanova).

2. *Endonasal Methods*

West's operation. Besides West we owe the modern methods of endonasal opening of the lacrimal sac to Polyak and Halle, who by 1913 gave a final shape to what is known as West's operation, which has remained without any substantial changes to date.

It should be noted, however, that a few years before West V. N. Okunev in his paper "Resection of the Nasolacrimal Duct in the Therapy of Lacrimal Diseases" published in 1907 reported an origi-

nal method of endonasal approach to the sac following the resection of the wall of the nasolacrimal duct.

West's endonasal operation is aimed to provide a wide communication between the lacrimal sac and the nose. The lacrimal sac is opened and its internal wall excised after the resection of the osseomucosal wall between the nose and the sac. Polyak, like V. N. Okunev, initially opened the sac through the nasolacrimal duct.

We shall describe West's operation as it has been performed by F. S. Bockstein, who has done much for the propagation of this method in the U.S.S.R.

The operation is usually performed on a patient in the sitting posture under local epimucous anesthesia, which for hypersensitive subjects is supplemented with a subperiosteal injection of 1 to 2 ml of a 1 per cent novocaine solution given above and below the internal palpebral ligament. Injection into the mucous membrane of the lateral wall of the nose is rarely applied since it involves infiltration of the mucous membrane and narrowing of the operative field. One example of how important it is to have a wide operative field is the resection of the nasal septum, which has to be used frequently in order to expand it.

The nasal mucosa having been cleansed of mucus, additional anesthesia is induced by painting it with 10 to 20 per cent cocaine solution with adrenalin repeated three times at intervals of two to three minutes. Anesthesia is applied to the mucous membrane of the nasal septum, the entire lateral wall of the nose, including the anterior portion of the inferior nasal turbinate, the middle nasal meatus and the anterior portion of the middle nasal turbinate. Moreover, the lacrimal sac is filled with a few drops of the same solution through the inferior canaliculus. For this the contents of the lacrimal sac are preliminarily expressed whereupon the lacrimal punctum and the lacrimal canaliculus are dilated first with a cone-tipped probe and then with a blunt cylindrical Bowman's probe. When opening an extremely tender lacrimal sac the bony opening is packed with a tampon soaked in a 10 per cent cocaine solution.

The operative techniques. The operation essentially consists of the following three stages: the excision of the nasal mucosa, resection of the bone, and removal of the internal wall of the lacrimal sac.

The first stage, i.e., excision of the mucosa of the lateral nasal wall in front of the head of the middle turbinate, is made in the portion corresponding to the torus lacrimalis. According to West this is performed in the following manner: the mucous membrane is cut down to the bone anteriorly to the middle nasal turbinate along the line *AB*, *BC*, *AD*, and *DC*, and the rhomboid flap thus formed is separated and removed. This is followed by additional incisions made along the nasal dorsum (*BE*) and along the edge of the apertura piriformis (*EF*). The flap *CBEF* is elevated from the underlying bone, folded along the *CF* axis and drawn backwards

(Fig. 95). F. S. Bockstein somewhat modified West's flap by making it wider and continuing the *BC* and *EF* vertical incisions downwards in order that the flap may be free to go down to the nasal floor without hazard of injury and enwrap the inferior nasal turbinate.

The second stage of the operation is the formation of a wide bony opening, 16 to 21 mm in size, in the posterior portion of the frontal process. The anterior ethmoid cells and the anterior end of the middle nasal turbinate often interfere with approach to this portion and in such cases have to be removed. It should be noted that West and Halle, unlike Polyak, rather than reach far backwards and upwards, contentthemselves with making a small bony opening, thereby usually obviating the need for resecting the ethmoid labyrinth or the middle nasal turbinate.

Considering that the lacrimal sac is likely to distend primarily outand downwards beyond the limits of the lacrimal fossa and down the frontal process, F. S. Bockstein recommends that those who use the common narrow and long grooved gouge, instead of West's gouges (West's gouges are shown in Fig. 96), for instance, Jansen's gouge, should dig rather far forwards and remove a considerable part of the posterior portion of the frontal process of the maxilla and the superior portion of the nasolacrimal duct, as described, i.e., make a wider bone resection than is recommended by West, which is particularly important in case of a distended sac. This procedure contributes to a better resection of the medial wall of the lacrimal sac. The internal part of the infraorbital boundary and the inferior portion of the crista lacrimalis anterior may at the same time be left intact, whereas in Toti's operation they are resected. To remove the bone in a whole piece F. S. Bockstein makes a deep horizontal cut in the bone,

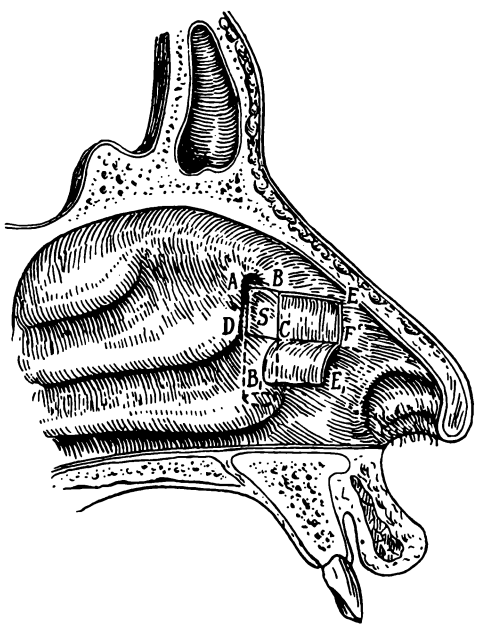


Fig. 95. West's operation. *ABCD*—a bony opening in the lateral wall of the nose through which the lacrimal sac (*S*) can be seen. *EF*, *EB*, *BC*—the line of cutting out a flap for expanding the operative field. *CBEF*—a flap separated from the mucosa of the lateral nasal wall and drawn downwards. The dotted line shows the nasolacrimal duct

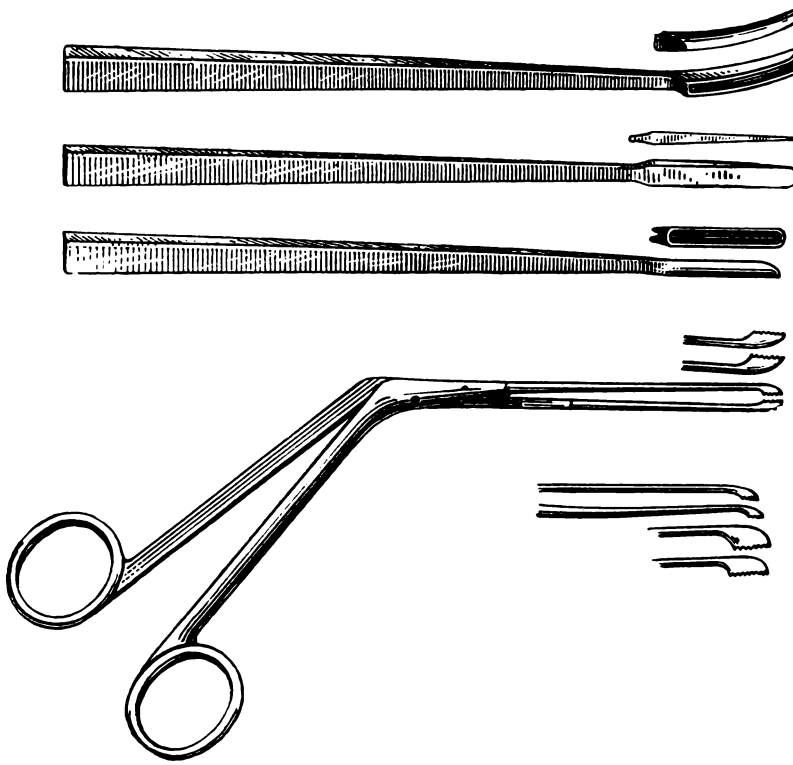


Fig. 96. West's instrumentarium

which is very thick in this place, and carries it from the fore backwards; the first blow is hit on the gouge set on the bone above and 8 to 10 mm anteriorly to the end of the middle turbinate, i.e., on the agger nasi, which corresponds to the highest point of the lacrimal sac. The second horizontal incision is made in similar fashion 1.5 cm below the first and parallel to it. The bone is then attacked vertically from the upper to the lower incision. The removal of the bone in a single piece is made by means of a strong forceps with light rotary movements. The resected part of the frontal process is often detached together with the adjoining cells of the ethmoid labyrinth and the lacrimal bone.

The third stage of the operation is resection of the internal wall of the lacrimal sac, which should be perfectly visible following the removal of bone.

West's method implies either removal of the medial wall or endonasal extirpation of the entire lacrimal sac. The resection of the medial wall of the sac is made by means of a conchotome introduced into the sac after it has been pushed into the nasal cavity by pressure of the forefinger on the inner angle of the eye and opened with a vertical incision (Fig. 97).

To verify whether the bony opening is wide enough a probe can be used, preliminarily slipped into the lacrimal sac through a lacri-

mal canaliculus; turning the probe in all directions it is possible to find out the degree of sac exposure and make sure that no obstruction exists in the communication passage.

After the wound has been carefully cleansed by all bony splinters wedged between the lateral nasal wall and the flap, the latter is set in place and covered with a few layers of gauze soaked in sterile liquid petrolatum. The gauze strips should be 5 to 6 cm lengthwise and 1 to 1.5 cm across. The tampons are removed one by one during 2 to 4 days after their being soaked with a 1 per cent cocaine solution with adrenalin and hydrogen peroxide.

Lacrimation ceases within 3 to 5 days of the operation. The postoperative treatment consists in cauterising the granulations with a 2 to 5 per cent silver nitrate solution or by removing them with a conchotome. The granulations usually grow during the first 4 to 6 weeks after the operation. After 5 to 6 months a relapse becomes unlikely.

Kofler's trans-septal method. Under this method the operation on the sac is performed through the opposite nostril, preceded by a partial resection of the nasal septum to provide a temporary through opening. In the view of some specialists, indications for this type of interference are quite limited. The method, however, has proved helpful for atresia of the nasal orifice on the affected side.

The trans-aperture method worked out by Weiss in 1920 and improved by N. S. Orembovsky (1925) and Claus (1927) consists in the endonasal opening of the lacrimal sac through the edge of the apertura piriformis.

This method has not met with wide acceptance, but it can be used for cases of marked concavity of the internal surface of the frontal process and a protrusion of the edge of the apertura piriformis, as well as for a narrow nasal structure (F. S. Bockstein).

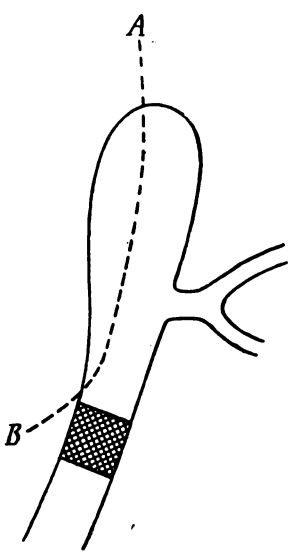


Fig. 97. The lacrimal sac with the lacrimal canaliculi. Shaded is the stenosed portion of the nasolacrimal duct. The dotted line *AB* indicates the vertical incision into the internal wall of the lacrimal sac

INDICATIONS FOR DACRYOCYSTORHINOTOMY, PARTICULARLY IN SELECTION BETWEEN EXTERNAL AND ENDONASAL METHODS OF FORMING AN ANASTOMOSIS

In M. I. Averbach's opinion, no contraindications exist for dacryocystorhinotomy as far as age, the state of the lacrimal passages, the eyes and the nose are concerned. Dupuy and Dutemps, as well as Bourguet believe that such contraindications are rare. This concept, however, is denied by a number of specialists, V. P. Strakhov in particular.

The absolute indications for the above-described operations are as follows: dacryocystitis, distentions of the lacrimal sac due to injury; chronic, acute and relapsing phlegmons and fistulas of the lacrimal sac; tuberculous lesions of the lacrimal sac, as well as the need for an early delivery of the conjunctival sac from its pathological, mostly pneumococcic, flora. This refers primarily to patients with dacryocystitis complicated by suppuration of the cornea, as well as to those awaiting an operation on the eye, such as excision of the cataract, optic iridectomy, operations for glaucoma, etc.

Selection of method. The question of choosing between the external and the endonasal methods has already been settled by practice: ophthalmologists operate extranasally, and rhinologists endonasally. In case the lacrimal sac is small and not distended, Toti's operation is advisable (without applying sutures), whereas a distended sac requires Dupuy-Dutemps' operation (with suturing).

The advantage of the endonasal approach to the lacrimal sac lies in the lesser danger of injury and absence of need for applying skin sutures, as well as an early expulsion of the pathogenic bacterial flora from the conjunctival sac. The advantage of the external approach to the sac lies in simpler procedures and a better vision of the operative field. At the same time, however, it involves the danger of injury to the lacrimal canaliculi both in elevating the soft tissues and in cicatrisation following the operation.

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TO THE READER

MIR Publishers would be grateful for your comments on the content, translation and design of this book. We would also be pleased to receive any other suggestions you may wish to make. Our address is: 2, Pervy Rizhsky Pereulok, Moscow, U.S.S.R.

Printed in the Union of Soviet Socialist Republics

Ф. И. ДОБРОМЫЛЬСКИЙ и
И. И. ЩЕРБАТОВ

**Придаточные пазухи носа
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Издательские редакторы
Е. Кольцова и М. Тихомирова
Технический редактор *В. Сизова*
Корректор *Ж. Суслович*

Сдано в производство 2/VIII 1966 г.
Подписано к печати 11/XI 1966 г.
Бумага 60×90¹/₁₆=7,50 бум. л. 15 печ. л.
в т/ч 12 вкл. Уч.-изд. л. 14,85.
Изд. № 17/3908
Цена 1 р. 40 к. Зак. 474
Тираж 10 000

ИЗДАТЕЛЬСТВО «МИР»
Москва, 1-й Рижский пер., 2

Московская типография № 16
Главполиграфпрома Комитета по печати
при Совете Министров СССР
Москва, Трехпрудный пер., 9